IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

PARKER-HANNIFIN CORPORATION,	)	
	)	
Plaintiff,	)	
	)	
v.	)	C.A. No. 07-104 (MPT)
	)	
SEIREN CO., LTD.,	)	
	)	
Defendant.	)	

DEFENDANT SEIREN CO., LTD.'s
OPENING BRIEF ON CLAIM CONSTRUCTION

MORRIS, NICHOLS, ARSHT & TUNNELL LLP
Jack B. Blumenfeld (#1014)
Julia Heaney (#3052)
1201 North Market Street
P.O. Box 1347
Wilmington, DE 19899-1347
(302) 658-9200
jheaney@mnat.com
Attorneys for Defendant Seiren Co., Ltd.

OF COUNSEL:

Scott M. Daniels
Ken-Ichi Hattori
Michael J. Caridi
WESTERMAN, HATTORI, DANIELS
& ADRIAN, LLP
1250 Connecticut Avenue, N.W.
Suite 700
Washington, DC 20036
(202) 822-1100

July 1, 2008

TABLE OF CONTENTS

TABLE OF AUTHORITIES

Page(s)

CASES

STATUTES

I. INTRODUCTION

There are three patents remaining in this case: U.S. Patent Nos. 6,521,348, 6,716,536 and 6,777,095 (Exhibits A, B & C, collectively the Bunyan Patents). The three patents are based on a series of continuation applications from a common parent and are each directed to flame retardant EMI shielding gaskets. Plaintiff Parker-Hannifin Corp. (Parker-Hannifin) initially asserted two other patents, U.S. Patent Nos. 6,248,393 and 6,387,523, in the original Complaint but has since withdrawn them.

Defendant Seiren Co., Ltd. (Seiren) hereby submits its opening brief addressing the proper construction of the '348, '536 and '095 patents.

II. THE LAW OF CLAIM CONSTRUCTION

It is a "bedrock principle" of patent law that "the claims of a patent define the invention to which the patentee is entitled the right to exclude." *Phillips v. AWN Corp.,* 415 F.3d 1303, 1312 (Fed. Cir. 2005) *(en banc).* The interpretation of patent claims is generally a matter of law, decided by the Court. *Markman v. Westview Instruments, Inc.,* 517 U.S. 370 (1996). Claim construction is "the process of giving proper meaning to the claim language." *Abtox, Inc. v. Exitron Corp.,* 122 F.3d 1019, 1023 (Fed. Cir. 1997).

A. The Goal of Claim Construction is to Determine the Claims' Meaning to a Person of Ordinary Skill in the Art.

A patent provides notice to the public of the patentee's exclusive rights, and the patent's claims define the scope of those rights. In *Phillips,* the Federal Circuit restated the basic principles of claim construction and reiterated that the goal is to determine the meaning of the claims to a person of ordinary skill in the art at the time the application for the patent was filed. *Phillips,* 415 F.3d at 1313 ("The descriptions in patents are not addressed to the public generally, to lawyers or to judges, but . . . to those skilled in the art to which the invention pertains or with

which it is most nearly connected.") (quoting *In re Nelson,* 280 F.2d 172, 181 (CCPA 1960)). The person of ordinary skill in the art is a theoretical construct who is presumed to be aware of all pertinent prior art and who possesses all the skills, experience and education commensurate with the sophistication of the particular technology. *Endress + Hauser, Inc. v. Hawk Measurement Sys. Pty. Ltd.,* 122 F.3d 1040, 1042 (Fed. Cir. 1997) (citations omitted); *In re GPAC Inc.,* 57 F.3d 1573, 1579 (Fed. Cir. 1995).

B. Sources of Evidence for Claim Construction

The four principle sources of evidence which may be used in construing claims are: (1) the language of the claims; (2) the specification; (3) the patent application's history of proceedings before the PTO; and (4) limited extrinsic evidence, such as dictionaries as objective sources of the common and ordinary meaning. *L.B. Plastics v. Amerimax Home Prods*., 499 F.3d 1303, 1308 (Fed. Cir. 2007).

1. The Language of the Claims is the Starting Point for Claim Construction

The patent claims define the scope of the patentee's exclusive rights. *Phillips,* 415 F.3d at 1312 (citation omitted).

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

35 U.S.C. § 112, ¶ 2.

The proper starting point, therefore, is always the language of the asserted claim itself. *Comark Communications, Inc. v. Harris Corp.,* 156 F.3d 1182, 1186 (Fed. Cir. 1998). Unless ambiguous or otherwise clearly modified by other intrinsic evidence, claim terms are given the ordinary and customary meaning that they would have to a person of ordinary skill in the relevant art at the time the patent application was filed. *Phillips,* 415 F.3d at 1312-1313

("The inquiry into how a person of ordinary skill in the art understands a claim term provides an objective baseline from which to begin claim interpretation.") (citation omitted).

Additionally, there is a presumption that each claim in a patent has a different scope. *Comark Comm.,* 156 F.3d at 1187. This difference is presumed to be significant when the absence of such difference in meaning and scope would render one of the claims superfluous. *Id.* (citation omitted).

2. Claims Must be Read in Light of the Specification, but the Specification does not Establish the Boundaries of the Claim

The first paragraph of 35 U. S. C. § 112, states that the specification must contain a written description in sufficient detail as to enable one skilled in the art to practice the claimed invention. Thus, the claims are read in view of the specification. However, because the specification is also meant to teach how to practice the invention, including the single best mode of using the invention, the specification can not be used as a source of claim limitations that do not appear in the claims themselves. *Markman v. Westview Instruments, Inc.,* 52 F.3d 967, 980 (Fed.Cir.1995) (en banc) ("The written description part of the specification itself does not delimit the right to exclude. That is the function and purpose of claims."); *SRI Intl v. Matsushita Elec. Corp. of America,* 775 F.2d 1107, 1121, n. 14 (Fed. Cir. 1985) ("Specifications teach. Claims claim.").

Claims are not restricted to the specific embodiments or examples that appear in the specification. *Phillips,* 415 F.3d at 1323. Similarly, figures or drawings in a patent which depict an embodiment of the invention do not limit the claims to that particular figure. *Electro Med. Sys. S.A. v. Cooper Life Sci. Inc.,* 34 F.3d 1048, 1054 (Fed. Cir. 1994) ("[P]articular embodiments appearing in a specification will not be read into the claims when the claim language is broader than such embodiments,"); *Playtex Prod., Inc, v. Proctor & Gamble* Co.,

400 F.3d 901, 908 (Fed. Cir. 2005) ("Claims of a patent may only be limited to a preferred embodiment by the express declaration of the patentee.") (citation omitted).

3. The Claims are also Read in Light of the Prosecution History

Another important source of intrinsic evidence in claim construction is the patent's prosecution history, which should be consulted as needed to determine the scope of a patent claim. *Phillips,* 415 F.3d at 1317 ("Like the specification, the prosecution history provides evidence of how the PTO and the inventor understood the patent."). However, claim scope is restricted only when the patentee uses "words or expressions of manifest exclusion or restriction" during prosecution or in the specification, which represent "a clear disavowal of claim scope." *Golight v. Wal-Mart,* 355 F.3d 1327, 1331 (Fed. Cir. 2004).

> Ultimately, the interpretation to be given a term can only be determined and confirmed with a full understanding of what the inventors actually invented and intended to envelop with the claim. The construction that stays true to the claim language and most naturally aligns with the patent's description of the invention will be, in the end, the correct construction.

Phillips, 415 F.3d at 1316.

4. Extrinsic Evidence can be Used to Assist the Court

Extrinsic evidence is any evidence not part of the claims, specification or prosecution history of the patent at issue. Extrinsic evidence can be used to provide background and assist the Court in understanding the technology at issue, such as how the invention works, or whether a particular claim term has a specialized meaning to one having ordinary skill in the art. *Phillips,* 415 F.3d at 1318. Because patent claims are to be construed as they would be understood by one having ordinary skill in the art at the time the invention was made, extrinsic evidence may be taken to "demonstrate the state of the prior art at the time of the invention." *Markman,* 52 F.3d at 980, 981. However, where a Court accepts extrinsic evidence, it is

important that it be used to assist with the Court's understanding and not to vary or contradict the terms of the claims. *Markman,* 52 F.3d at 981.

III. THE PROPER CONSTRUCTION OF THE PATENT CLAIMS

A. The Level of Ordinary Skill in the Art

As stated above, claim terms are generally given the meaning that they would have to a person of ordinary skill in the pertinent art at the time of the invention. As explained in the Bunyan patents, the pertinent field of the invention is "an electrically-conductive fabric having a layer of a flame retardant coating applied to one surface thereof for use as a sheathing within an EMI shielding gasket." (Exhibit A, 1:19-22).[1]

A person of ordinary skill in the art at the time of the invention of the Bunyan patents would be familiar with the design and properties of flame retardant EMI shielding gaskets, and would have either (1) six years or more of work experience in the design and/or manufacture of flame retardant EMI shielding gaskets, or (2) three years or more of work experience in the design and/or manufacture of flame retardant EMI shielding gaskets, along with a bachelor's degree in chemistry or a related field.

B. The Bunyan Patents

1. The Claims

Claim 1 of the '348 patent is representative of the claims of the '348, '536 and '095 patents and recites:

> A flame retardant, electromagnetic interference (EMI) shielding gasket comprising:
>
> a resilient core member which is ***not V-0 rated*** under Underwriter's Laboratories (UL) Standard No. 94 extending

[1] For the sake of clarity, the column/line numbers from the '348 patent are used herein to refer to the disclosure of each of the three patents.

> lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis,
>
> said core member being formed of a foamed elastomeric material;
>
> an electrically-conductive fabric member surrounding the outer surface of said core member,
>
> said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface,
>
> at least the ***exterior surface*** being electrically-conductive and the exterior surface defining with the interior surface a ***thickness dimension*** of the fabric member therebetween;
>
> and a flame retardant layer ***coating at least a portion of the interior surface*** of said fabric member,
>
> said flame retardant layer being effective to afford said gasket a flame class ***rating of V-0*** under Underwriter's Laboratories (UL) Standard No. 94 and ***penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive***.

(Emphasis added).

Claim 8 of the '348 patent and the claims in dispute in the '536 and '095 patents contain the same terms emphasized above. Claim 8 of the '348 patent, claim 1 of the '536 patent, and claim 1 of the '095 patent each recites a flame retardant content. Seiren submits that these limitations cannot be construed and addresses them at the end of this Brief.

2. The Bunyan Specification

The Abstract of the Bunyan specification indicates that the disclosure relates to a "flame retardant, electrically-conductive EMI shielding material and method, the material being particularly adapted for use in fabric-over-foam EMI shielding gasket constructions."

The Bunyan specification begins by identifying interference with the operation of electronic equipment from electromagnetic radiation within the electronic circuitry of the

equipment (1:17-21). This interference, the Bunyan specification states, has been dealt with by shielding the equipment with a radiation barrier housing. Since access to the equipment is necessary, there must be gaps in the housing, such gaps reducing the shielding efficiency of the housing and sometimes even being a "secondary" source of radiation (1:39-47).

Gaskets and other seals have been proposed both for filling gaps within mating surfaces of housings and other EMI shielding structures for maintaining electrical continuity across the structure, and for excluding from the interior of the device such contaminates as moisture and dust (1:54-58). These seals provide *electrical surface conductivity* even while under compression, but also have a resiliency allowing the seals to conform to the size of the gap; the seals additionally must be wear resistant, economical to manufacture, capable of withstanding repeated compression and relaxation cycles (1:63-2:3); and they often possess a low impedance, low profile gasket structure which is deflectable under normal closure force loads (2:8-10). The gaskets must also be flame retardant, *i.e.*, achieve a *rating of V-0* under UL Std. No. 94, "Tests for Flammability of Plastic Materials for Parts in Devices and Appliances" (1991), without compromising the electrical conductivity necessary for meeting EMI shielding requirements (2:49-54).

The Bunyan specification then describes a specific gasket which consists of an electrically-conductive jacket or sheathing which is "cigarette" wrapped lengthwise over a polyurethane or other foam core (the polyurethane foams generally are produced by the reaction of polyisocyanate and a hydroxyl-functional polyol in the presence of a blowing agent); the blowing agent effects the expansion of the polymer structure into a multiplicity of open or closed cells (2:21-28). The foamed polymeric materials are flammable due to their cellular structure, high organic content and surface area (2:58-61).

A proposed solution to this problem of flammability with foam gaskets is to sheath the foam within an electrically-conductive Ni/Cu-plated fabric to which a thermoplastic sheet is hot nipped or otherwise fusion bonded to the underside thereof (2:64-2:3). Another proposed solution is to apply a supplemental layer or coating to the interior surface of the sheath. The coating may be a flame-retardant urethane formulation which also promotes the adhesion of the sheath to the foam, and may additionally function to reduce bleeding of the foam through the fabric which otherwise could compromise the electrical conductivity of the sheath (3:9-16).

In the broad statement of the invention, the Bunyan specification states that the flame retardant layer may be wet coated on the fabric without appreciable bleed through a relatively thin (*i.e.*, 2-4 mil) coating layer provided on one fabric side without compromising the electrical surface conductivity of the other side (3:32-37). In use the fabric may be wrapped around the foam as a jacket, the coated side of the fabric being the interior surface adjacent the foam, and the uncoated side being the electrically-conductive exterior surface. The coating on the interior surface of the jacket *blocks the pores* of the fabric to retain the foam therein without penetrating or bleeding through to the exterior surface (3:60-66).

The Bunyan specification includes a single example, from which it draws the conclusion that "[u]nexpectedly, it was found that a relatively porous or permeable fabric may be wet coated on one side with a relatively thin, *i.e.,* 2-4 mil (0.05-0.10 mm), coating layer of a flame retardant composition without compromising the electrical surface conductivity of the other side." (10:24-28).

3. The Bunyan Prosecution History

The application which resulted in the '348 patent contained seven original claims.

In an office action dated August 9, 2002, the examiner rejected the pending claims under 35 U.S.C. § 112, ¶1, because the claims were broader in scope then the enablement of the specification. The examiner asserted that the specification was enabling for gaskets in which "the flame retardant coating does not penetrate to the full depth of the fabric member, so as to retain the electrical conductivity of the side not penetrated by flame retardant composition" but that the disclosure did not, however, enable one in the art to make *any* EMI shielding construction.[2]

Additionally, the Examiner rejected the pending claims for obviousness-type double patenting over claim 1-8 of U.S. Patent No. 6,387,523. The examiner stated:

> the conflicting claims are not identical, they are not patentably distinct from each other because claims 1-7 do not claim the depth of the fabric that is penetrated, as does [USP] 6,387,523. However, the specification of the instant application very clearly specifies that the fabric member has delimited the penetration by the flame retardant composition.

Applicants responded to the rejection by limiting claim 1 to the scope of enablement found by the examiner in the specification. Specifically, claim 1 was amended to recite (1) that the resilient core member "is not V-0 rated under Underwriter's Laboratories (UL) Standard No. 94," (2) that "at least the exterior surface [is] electrically-conductive and the exterior surface [defines] with the interior surface a thickness dimension of the fabric member therebetween," and (3) that the flame retardant layer penetrates "into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior

[2] The examiner also made a minor comment regarding claim 3.

surface of said fabric member remains electrically-conductive." Applicants also added claims 8-18 as they appear in the '348 patent.

In their accompanying remarks, applicants implied that the amendment of claim 1 was in response to the enablement rejection. With respect to the double patenting rejection, applicants filed a terminal disclaimer.

Applicants also referred to the recitation in new claim 8 of the flame retardant layer comprising between about 30-50% by weight of one or more flame retardant additives:

> it is believed that the adhesive or other layers previously used in the art were not so highly loaded with flame retardant additives such that a gasket constructed therewith could achieve a UL rating of V0 notwithstanding that the other component part thereof, namely the core, were not in and of themselves V0 rated. Rather, it is believed that conventional wisdom called for each of the components of the gasket to be V0-rated for achieving an overall gasket construction having a V0 rating. It remained for the instant Applicants, however, to recognize that a V0-rated gasket could be constructed without the core itself having to be V0-rated.

The examiner then allowed the application without a statement of reasons, and the '348 patent issued on February 18, 2003.

The prosecution history of the applications which resulted in the '536 and '095 patents raised similar enablement and double patenting issues. The applicants addressed them in similar fashion by amending the independent claims to recite (1) that "at least the exterior surface [is] electrically-conductive and the exterior surface [defines] with the interior surface a thickness dimension of the fabric member therebetween," and (2) that the flame retardant layer (a) has the flame retardant contents recited in those patents and (b) penetrates "into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive."

C. Construction of the Bunyan Claims

a. "…not V-0 rated…"

Claim 1 of the '348 patent clearly and unequivocally recites "a resilient core member which is ***not V-0 rated*** under Underwriter's Laboratories (UL) Standard No. 94." The direct, unqualified wording of the claim itself controls. It means simply that the "core member" has not received a V-0 rating under Underwriter's Laboratories UL Standard No. 94.

The Bunyan specification refers to "core member 52" (Exhibit A, 7:57-8:12), but never suggests the core member is *merely capable* of affording a V-0 rating as proposed by Parker-Hannifin (*i.e.*, that the core member *would* not be V-0 rated *if* it were tested according to UL Standard No. 94). Similarly, nothing in the '348 prosecution suggests such a meaning. If the '348 applicants had wanted to focus on the *capability* or *effect* of the core member, rather than its *actual rating*, they could have done so as they did with the flame retardant layer which is recited as "being effective to afford said gasket a flame class rating of V-0."

b. "…exterior surface…", "…interior surface…"

Claim 1 refers to "the **exterior surface** being electrically-conductive and the **exterior surface** defining with the **interior surface** a thickness dimension of the fabric member therebetween." The "exterior surface" refers to the outer face, outside or exterior boundary of the fabric member, and the "interior surface" refers to the inner face, inside or interior boundary of the fabric member.

This understanding of "surface" is supported by the Bunyan specification which invariably discloses the flame retardant composition coated on the "exterior boundary" of the conductive fabric. (*See* Exhibit A, Fig. 6; 1:20-22 ("a flame retardant coating applied to one surface thereof"); 3:16-17 ("coating applied to the interior surface of the sheath); 7:34-35 ("Core

member 52 has an outer circumferential surface, 54"); 8:50-51 ("exposed on the exterior surface of the gasket"); 9:65-67 ("the emulsion was delivered to the surface of the cloth")).

This construction of claim 1 is confirmed by dictionaries. The word "surface" is defined to mean "outside of a thing… any of the limits of a solid" (*see Exhibit D, The Oxford Desk Dictionary,* 579 (1995)). The word "exterior" is defined to mean "of or on the outside surface" (*see* Exhibit *D, The Oxford Desk Dictionary,* 200 (1995)). *See L.B. Plastics v. Amerimax Home Prods*., 499 F.3d 1303, 1308 (Fed. Cir. 2007) (confirming the use of general purpose dictionaries).

Parker-Hannifin defines these claims terms by merely repeating the words "interior," "exterior" and "surface."

c. "…thickness dimension…"

Claim 1 recites that the exterior surface and the interior surface of the fabric member define the "thickness dimension" of the fabric member.

Parker-Hannifin again defines the claim words by the words themselves, without any reference to the Bunyan specification, as the "distance between the exterior surface …and the interior surface…." In fact, the Bunyan specification graphically shows the "thickness dimension" in Fig. 2 to be the distance represented by "t_1."

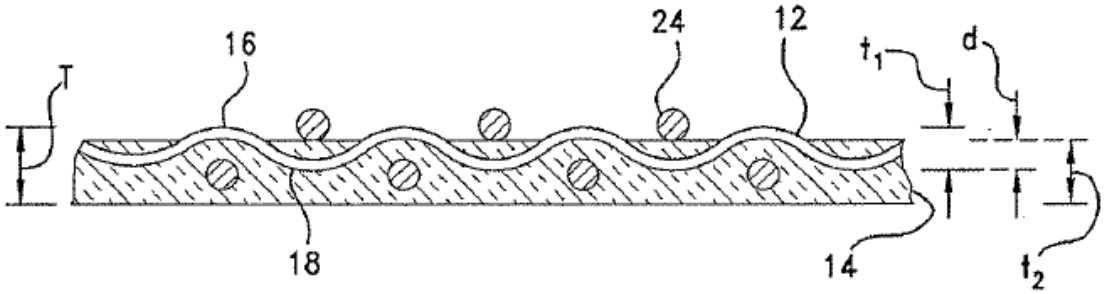


Fig. 2

The accompanying text of the Bunyan specification explains that "the viscosity and hydrodynamic pressure of the resin composition are controlled in accordance with the precepts of the present invention to delimit the penetration of the resin layer to a depth, referenced at "d" in FIG. 2, which is *less than the thickness dimension t_1 of the fabric member* 12. (Exhibit A, 6:38-44; emphasis). The Bunyan specification could not be clearer.

Moreover, Parker-Hannifin's construction of the expression does not take into account the undulating nature of the warp and weft threads. That undulation results in variation of exterior surface/interior surface thicknesses, depending upon the location at which measurement is taken. Such variation depending upon the point of measurement would render the claims indefinite.

Claim 1 should therefore be construed according to the Bunyan specification, not to Parker-Hannifin's variable standard that would make it indefinite. *Generation II Orthotics Inc. v. Med. Tech., Inc*., 263 F.3d 1356 (Fed. Cir. 2001) (claims should be construed, if possible, to support their validity).

d. "…coating at least a portion of the interior surface…"

The claim recitation "coating at least a portion of the interior surface" means that flame retardant layer is *applied directly* to the interior surface of the fabric member, covering at least a portion of that interior surface. Such direct application of the flame retardant to the interior surface of the fabric is indicated by the definition of the claim terms "exterior surface" and "interior surface" discussed above.

It is also indicated by the Bunyan specification which invariably discloses direct application of the flame retardant to the fabric member. (*E.g*., Exhibit A, Fig. 6 showing direct application of the flame retardant to the fabric). Note also that in the "Broad Statement of the

Invention," the coating on the interior surface of the jacket is described as *blocking the pores* of the fabric to retain the foam therein without penetrating or bleeding through to the exterior surface (Exhibit A, 3:60-66). At no point does the Bunyan specification disclose indirect application of the flame retardant, *i.e.*, application of the flame retardant to an intermediate layer of the fabric.

Seiren's definition is also consistent with the Federal Circuit's claim construction in *Power Mosfet Techs. v. Siemens AG*, 378 F.3d 1396 (Fed. Cir. 2004). There, the claim recited a semiconductor device in which a "second contact layer contacting with all the first and second semiconductor regions to form a second interface." The Federal Circuit construed the limitation to require direct physical contact between the contact layer and the semiconductor regions, despite the fact that the claim did not recite the word "direct," whereas other claims in the patent did. 378 F.3d at 1403, 1407-1410. Similarly, the recitation in claim 1, "coating at least a portion of the interior surface," means that flame retardant layer is *applied directly* to the interior surface of the fabric member.

e. "…rating of V-0…"

Claim 1 recites a "flame retardant layer being effective to afford said gasket a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94." Claim 1 thus refers to the capability of the flame retardant layer, rather to the actual rating it achieves for the claimed gasket. The claim expression "rating of V-0" means that the gasket would receive a V-0 rating if it were tested according to Underwriter's Laboratories (UL).

If claim 1 were construed as urged by Parker-Hannifin -- the gasket "has been accorded a V-0 rating by UL after testing for flammability under UL Standard No. 94" – the claim words "effective to afford" would lose their meaning. *Innova/Pure Water, Inc. v. Safari*

Water Filtration Sys.,Inc., 381 F.3d 1111, 1119 (Fed. Cir. 2004) (every term is presumed to add some meaning to the claim).

Moreover, if Parker-Hannifin wanted the direct definition of the gasket it now proposes, it could have used the type of simple declarative wording used in connection with the core member – *e.g.*, "the gasket is V-0 rated under UL Standard No. 94."

f. ***"…penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive …"***

Claim 1 describes the flame retardant layer "penetrating into said fabric member …such that the exterior surface of said fabric member remains electrically conductive." Thus, the degree of flame penetration into the fabric is recited in functional terms, *i.e.*, so that the exterior surface of the fabric remains "electrically conductive." This term, "electrically conductive," is expressly defined in the Bunyan specification as meaning "that the fabric may be rendered conductive, *i.e.*, to a *surface resistivity of about 0.1 Ω/sq or less* by reason of the conductive materials in the fabric. (Exhibit A, 5:46-48; emphasis added). This is an explicit definition of the claim term, not merely a reference to a preferred embodiment.

Accordingly, the limitation means that the flame retardant layer does not penetrate the fabric member to an extent that would cause the exterior surface of the fabric member to have a surface resistivity "greater than about 0.1 Ω/sq."

This interpretation is supported by the specification, particularly Fig. 2 which shows some entry of the flame retardant into the fabric. As a practical matter, such entry is needed to maintain the physical union of the fabric member and the flame retardant layer because they would not react in a manner needed to chemically maintain that union.

Dictionary definitions of "penetrate" also support this interpretation, for instance the definition of "penetrate" as "find access into or through…pierce…permeate." *See Exhibit D, The Oxford Desk Dictionary,* 425 (1995). Such penetration, however, must be controlled so that the first side of the porous fabric member remains electrically conductive – the "surface conductivity of the opposite side of the fabric therefore is not compromised in EMI shielding applications." (Exhibit A, 3:59-61).

It is not uncommon for courts to construe a claim term according to mathematical values expressly disclosed in the specification. In *Modine Mfg. Co. v. United States Int'l Trade Comm'n*, the patent claimed a condenser for a refrigerant in a cooling system comprising, *inter alia*, flow paths of "relatively small hydraulic diameter." The Federal Circuit held that the public was entitled to rely on the disclosure in the specification of the numeric range "about 0.015-0.040 inch" as a definition for "relatively small." 75 F.3d 1545, 1552 (Fed. Cir. 1996). Similarly, in *Hoechst Celanese Corp. v. BP Chemicals, Ltd*., the Federal Circuit construed a claim term to have a specific numerical value in view of the disclosure in the specification: "[b]y the term 'stable,' it is meant that the resin will not chemically decompose, or change more than about 50 percent of its dry physical dimension upon being exposed to the organic medium containing the iodide compounds." 78 F.3d 1757 (Fed. Cir. 1996).[3]

[3] *See also Rhodia Chimie v. PPG Indus*., where the claimed invention was a composition of "dust-free and non-dusting" silica particulates for use as a filler. The Federal Circuit found that the expression "dust-free and non-dusting" could not be construed to mean "no dust at all" because the specification stated that the invention produced at least some dust, though less dust than the prior art. The Federal Circuit therefore relied on two examples from the specification to determine that the claimed invention was limited to embodiments having either the specific dust content of one of the examples or a lower value. 402 F.3d 1371, 1380 (Fed. Cir. 2005).

g. the remaining claims

Claim 8 of the ’348 patent and the claims in dispute in the ’536 and ’095 patents contain the same terms discussed above, and the same analysis applies to them as well. Seiren’s claim construction for all three patents is summarized in the charts below.

U.S. Patent No. 6,521,348

Claim	Claim Element	Claim Constructions
1	A flame retardant, electromagnetic interference (EMI) shielding gasket comprising: a resilient core member which is **not V-0 rated** under Underwriter’s Laboratories (UL) Standard No. 94 extending lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis,	“…**not V-0 rated…**” means The “core member” has not received a V-0 rating under Underwriter’s Laboratories UL Standard No. 94.
	said core member being formed of a foamed elastomeric material;	
	an electrically-conductive fabric member surrounding the outer surface of said core member,	
	said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface,	
	at least the **exterior surface** being electrically-conductive and the exterior surface defining with the interior surface a **thickness dimension** of the fabric member therebetween;	**“…exterior surface…”** means The outer face, outside or exterior boundary of the fabric member. **“…thickness dimension…”** means The dimension represented by “t_1” in Fig. 2.
	and a flame retardant layer **coating at least a portion of the interior surface** of said fabric member,	**“…coating at least a portion of the interior surface…”** means The flame retardant layer is directly applied to the interior surface of the fabric member, covering at least a portion of that interior surface.

	said flame retardant layer being effective to afford said gasket a flame class **rating of V-0** under Underwriter's Laboratories (UL) Standard No. 94 and **penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive.**	**"…rating of V-0…"** means The "gasket" would receive a V-0 rating if it were tested according to Underwriter's Laboratories (UL) Standard No. 94. **"…penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive."** means The flame retardant layer does not penetrate the fabric member to an extent that would cause the exterior surface of the fabric member to have a surface resistivity greater than about 0.1 Ω/sq.
8	A flame retardant, electromagnetic interference (EMI) shielding gasket comprising: a resilient core member extending lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis,	
	said core member being formed of a foamed elastomeric material;	
	an electrically-conductive fabric member surrounding the outer surface of said core member, said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface,	

	at least the **exterior surface** being electrically-conductive and the exterior surface defining with the interior surface a **thickness dimension** of the fabric member therebetween;	**"…exterior surface…"** means The outer face, outside or exterior boundary of the fabric member. **"…thickness dimension…"** means The dimension represented by "t_1" in Fig. 2.

	and a flame retardant layer **coating at least a portion of the interior surface** of said fabric member,	**"…coating at least a portion of the interior surface…"** means The flame retardant layer is directly applied to the interior surface of the fabric member, covering at least a portion of that interior surface.
	said flame retardant layer comprising **between about 30-50% by weight** of one or more flame retardant additives and **penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive.**	The weight limitation is indefinite. **"…penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive."** means The flame retardant layer does not penetrate the fabric member to an extent that would cause the exterior surface of the fabric member to have a surface resistivity greater than about 0.1 Ω/sq.
15	The gasket of claim 8 wherein said flame retardant layer is effective to afford the gasket a flame class **rating of V-0** under Underwriter's Laboratories (UL) Standard No. 94.	**"… rating of V-0..."** means The "gasket" would receive a V-0 rating if it were tested according to Underwriter's Laboratories (UL) Standard No. 94.

U.S. Patent No. 6,716,536

Claim	Claim Element	Claim Constructions
1	A flame retardant**,** electromagnetic interference (EMI) shielding gasket comprising:	
	a resilient core member extending lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis,	
	said core member being formed of a foamed elastomeric material;	

	an electrically-conductive fabric member surrounding the outer surface of said core member,	
	said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface,	
	at least the **exterior surface** being electrically-conductive and the exterior surface defining with the interior surface a **thickness dimension** of the fabric member therebetween;	**"…exterior surface…"** means The outer face, outside or exterior boundary of the fabric member. **"…thickness dimension…"** means The dimension represented by "t_1" in Fig. 2.
	and a flame retardant layer **coating at least a portion of the interior surface** of said fabric member,	**"…coating at least a portion of the interior surface…"** means The flame retardant layer is directly applied to the interior surface of the fabric member, covering at least a portion of that interior surface.
	said flame retardant layer comprising **at least about 30% by weight** of one or more flame retardant additives and **penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive.**	The weight limitation is indefinite. **"…penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive."** means The flame retardant layer does not penetrate the fabric member to an extent that would cause the exterior surface of the fabric member to have a surface resistivity greater than about 0.1 Ω/sq.
8	The gasket of claim 1 wherein said flame retardant layer is effective to afford the gasket a flame class **rating of V-0 under** Underwriter's Laboratories (UL) Standard No. 94.	**"… rating of V-0..."** means

		The "gasket" would receive a V-0 rating if it were tested according to Underwriter's Laboratories (UL) Standard No. 94.

U.S. Patent No. 6,777,095

Claim	Claim Element	Claim Constructions
1	A flame retardant, electromagnetic interference (EMI) shielding gasket comprising:	
	a resilient core member extending lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis,	
	said core member being formed of a foamed elastomeric material;	
	an electrically-conductive fabric member surrounding the outer surface of said core member,	
	said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface,	
	at least the **exterior surface** being electrically-conductive and the exterior surface defining with the interior surface a **thickness dimension** of the fabric member therebetween; and	**"…exterior surface…"** means The outer face, outside or exterior boundary of the fabric member. **"…thickness dimension…"** means The dimension represented by "t_1" in Fig. 2.
	a flame retardant layer **coating at least a portion of the interior surface** of said fabric member,	**"…coating at least a portion of the interior surface…"** means The flame retardant layer is directly applied to the interior surface of the fabric member, covering at least a portion of that interior surface.

	said flame retardant layer comprising **at least about 50% by dry weight** of one or more flame retardant additives and **penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive.**	The weight limitation is indefinite. **"…penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive."** means The flame retardant layer does not penetrate the fabric member to an extent that would cause the exterior surface of the fabric member to have a surface resistivity greater than about 0.1 Ω/sq.

D. The Flame Retardant Content Limitations Are Indefinite

A patent claim is invalid if it fails to meet the definiteness requirement under 35 U.S.C §112. If a court determines that a claim limitation does not provide meaningfully precise claim scope, even if it can be reduced to words, then the claim is indefinite as a matter of law. *Halliburton Energy Svcs. v. M-I LLC*, 514 F.3d 1244, 1251 (Fed. Cir. 2008).

Claim 8 of the '348 patent and claim 1 of the '536 patent recite that the flame retardant layer comprises an amount of flame retardant "by weight," but fail to state whether the content is wet weight or dry weight. Claim 1 of the '095 patent recites that the flame retardant layer comprises an amount of flame retardant "by dry weight," but the intrinsic record fails to disclose how to perform a "dry weight" measurement on the claimed, finished gasket, other than by referring to the characteristics of a liquid emulsion during its application in gasket manufacture. Thus, the claim terms "by weight" and "by dry weight" do not give objective notice to the public of what is covered by the claim. *Honeywell Int'l, Inc. v. Int'l Trade Comm'n*, 341 F.3d 1332, 1339 (Fed. Cir. 2003) (where alternative protocols are possible and

there is no guidance in the intrinsic record as to which protocol to follow, the claim is invalid as indefinite).

V. CONCLUSION

For the reasons stated, Defendant Seiren Co., Ltd., requests that the claim terms in dispute be construed as discussed above.

MORRIS, NICHOLS, ARSHT & TUNNELL LLP

/s/ Julia Heaney
Jack B. Blumenfeld (#1014)
Julia Heaney (#3052)
1201 North Market Street
P.O. Box 1347
Wilmington, DE 19899-1347
(302) 658-9200
jheaney@mnat.com
Attorneys for Defendant Seiren Co., Ltd.

OF COUNSEL:

Scott M. Daniels
Ken-Ichi Hattori
Michael J. Caridi
WESTERMAN, HATTORI, DANIELS & ADRIAN, LLP
1250 Connecticut Avenue, N.W.
Suite 700
Washington, DC 20036
(202) 822-1100

July 1, 2008
2392100

CERTIFICATE OF SERVICE

I hereby certify that on July 1, 2008 I electronically filed the foregoing with the Clerk of the Court using CM/ECF, which will send notification of such filing to:

Rudolf E. Hutz, Esquire
Francis DiGiovanni, Esquire
CONNOLLY BOVE LODGE & HUTZ LLP

I further certify that I caused to be served copies of the foregoing document on July 1, 2008 upon the following in the manner indicated:

BY E-MAIL

Rudolf E. Hutz, Esquire
Francis DiGiovanni, Esquire
Connolly Bove Lodge & Hutz LLP
The Nemours Building
1007 N. Orange Street
Wilmington, DE 19801

/s/ Julia Heaney

Julia Heaney (#3052)

EXHIBIT A

EXHIBIT A

US006521348B2

(12) **United States Patent**
Bunyan et al.

(10) **Patent No.: US 6,521,348 B2**
(45) **Date of Patent: *Feb. 18, 2003**

(54) **FLAME RETARDANT EMI SHIELDING GASKET**

(75) Inventors: **Michael H. Bunyan**, Chelmsford, MA (US); **William I. Flanders**, Merimack, NH (US)

(73) Assignee: **Parker-Hannifin Corp.**, Cleveland, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/142,803**

(22) Filed: **May 9, 2002**

(65) **Prior Publication Data**

US 2002/0125026 A1 Sep. 12, 2002

Related U.S. Application Data

(63) Continuation of application No. 09/883,785, filed on Jun. 18, 2001, now Pat. No. 6,387,523, which is a continuation of application No. 09/250,338, filed on Feb. 16, 1999, now Pat. No. 6,428,393.

(60) Provisional application No. 60/076,370, filed on Feb. 27, 1998.

(51) **Int. Cl.**[7] **B32B 5/14**; B32B 5/18; H05K 9/00

(52) **U.S. Cl.** **428/457**; 361/818

(58) **Field of Search** 427/77; 361/818; 428/457

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,178,410	A	12/1979	Tomita
4,396,661	A	8/1983	George et al.
4,447,484	A	5/1984	Slosberg et al.
4,489,126	A	12/1984	Holtrop et al.
4,531,994	A	7/1985	Holtrop et al.
4,540,617	A	9/1985	Kawanishi et al.
4,569,304	A	2/1986	Le Maitre
4,572,960	A	2/1986	Ebneth et al.
4,608,104	A	8/1986	Holtrop et al.
4,621,013	A	11/1986	Holtrop et al.

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

DE	9013936	12/1990
EP	0326441	8/1989
FR	2308030	11/1976
JP	07-176889	* 7/1995
WO	WO 00/23513	* 4/2000
WO	WO 01/10182	* 2/2001

OTHER PUBLICATIONS

Dye, James M. Compliance Engineering 17(3), pp 138 and 140–145, 2000.*

Kleiner, J. Vinyl Technol. vol. 4 No. 4, Dec. 1982, pp 157–159, 1982.*

Copy of the International Application Published Under the Patent Cooperation Treaty in International Patent Application No. PCT/US00/20609 (WO 01/10182) entitled: "Method and Apparatus for Manufacturing A Flame Retardant EMI Gasket".

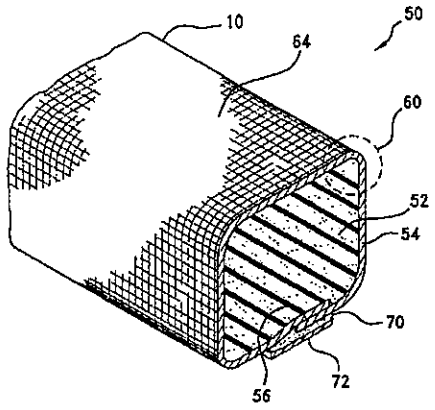
(List continued on next page.)

Primary Examiner—Erma Cameron
(74) *Attorney, Agent, or Firm*—John A. Molnar, Jr.

(57) **ABSTRACT**

A flame retardant, electromagnetic interference (EMI) shielding gasket construction. The construction includes a resilient core member formed of a foamed elastomeric material, an electrically-conductive fabric member surrounding the outer surface of the core member, and a flame retardant layer coating at least a portion of the interior surface of the fabric member. The flame retardant layer is effective to afford the gasket construction with a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94.

18 Claims, 3 Drawing Sheets



U.S. PATENT DOCUMENTS

4,666,765	A	5/1987	Caldwell et al.	
4,684,762	A	8/1987	Gladfeiter	
4,753,840	A	6/1988	Van Gompel	
4,797,171	A	1/1989	Van Gompel	
4,857,668	A	8/1989	Buonanno	
4,871,477	A	10/1989	Dimanshteyn	
4,988,550	A	1/1991	Keyser et al.	
5,009,927	A	4/1991	Cloyd et al.	
5,028,739	A	7/1991	Keyser et al.	
5,045,635	A	9/1991	Kaplo et al.	
5,089,325	A	2/1992	Covey	
5,105,056	A	4/1992	Hoge, Jr. et al.	
5,122,411	A	6/1992	Iwamoto et al.	
5,202,536	A	4/1993	Buonanno	
5,204,403	A	4/1993	Furuta et al.	
5,266,354	A	11/1993	Tohyama et al.	
5,612,092	A	3/1997	Strenger et al.	
5,614,306	A	3/1997	Jobe et al.	
5,635,252	A	6/1997	Fraser, Jr. et al.	
5,641,544	A	6/1997	Melancon et al.	
5,674,606	A	10/1997	Powers, Jr.	
5,700,532	A	12/1997	Chiou	
2001/0028558	A1 *	10/2001	Rapp et al.	361/818

OTHER PUBLICATIONS

Chomerics Parker Hannifin Seals Catalog dated 1997 for Soft-Shield Low Closure Force EMI Gaskets.
Monsanto Flectron Metalized Materials dated Sep. 12, 1995.
Copy of International Search Report for PCT Case No. PCT/US99/04100, Jan. 7, 1999.
Underwriters Laboratories, Inc. letter dated Sep. 20, 1995.

* cited by examiner

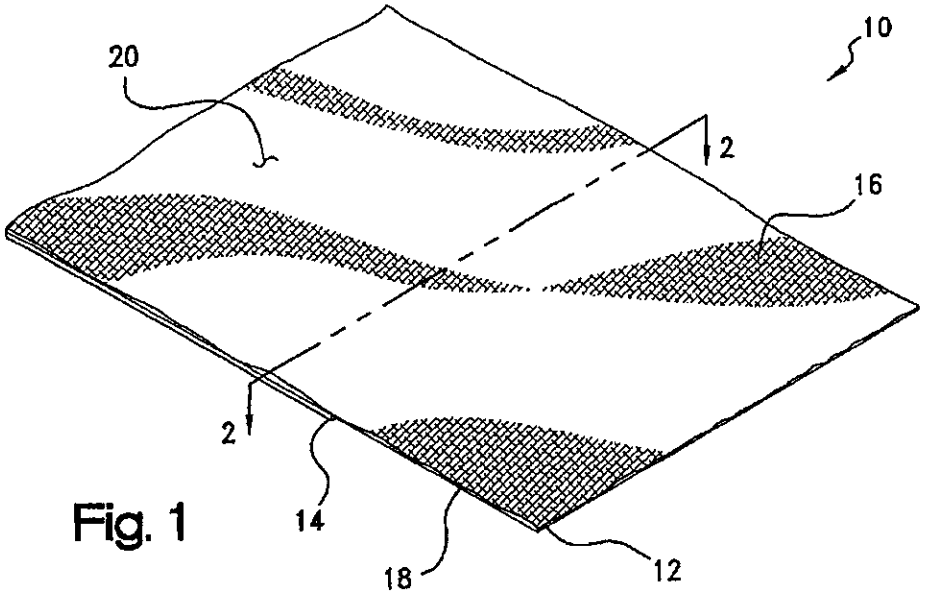


Fig. 1

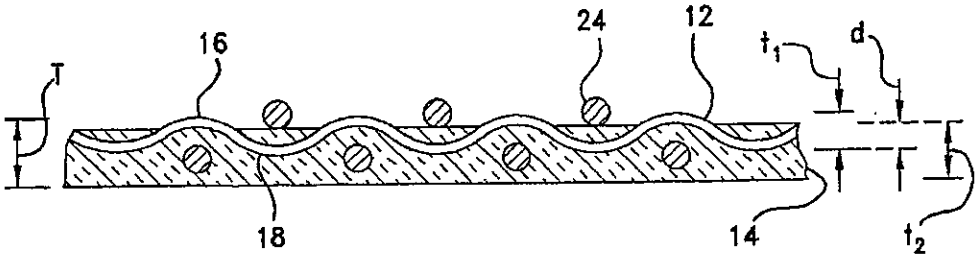


Fig. 2

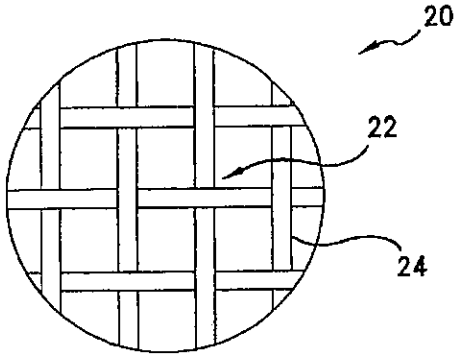


Fig. 3

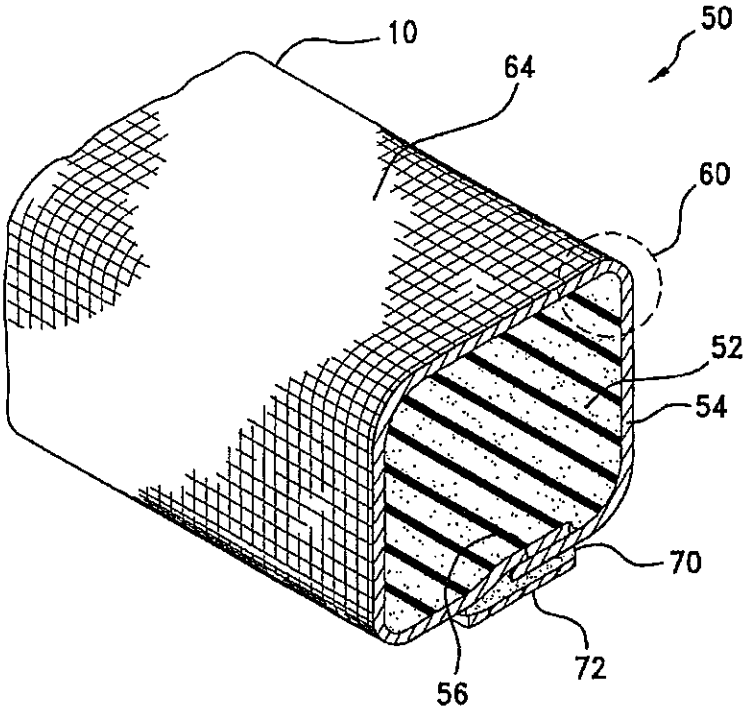


Fig. 4

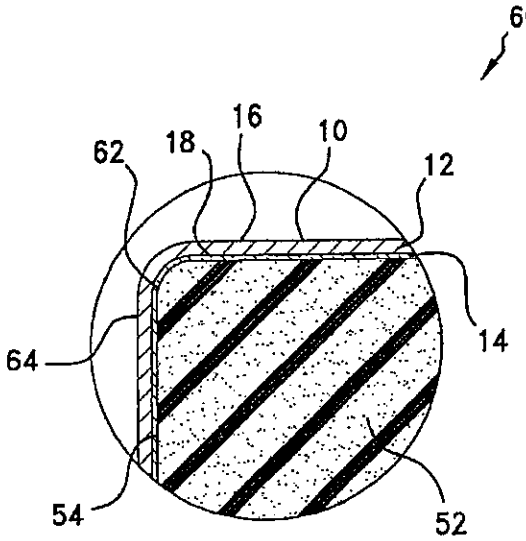


Fig. 5

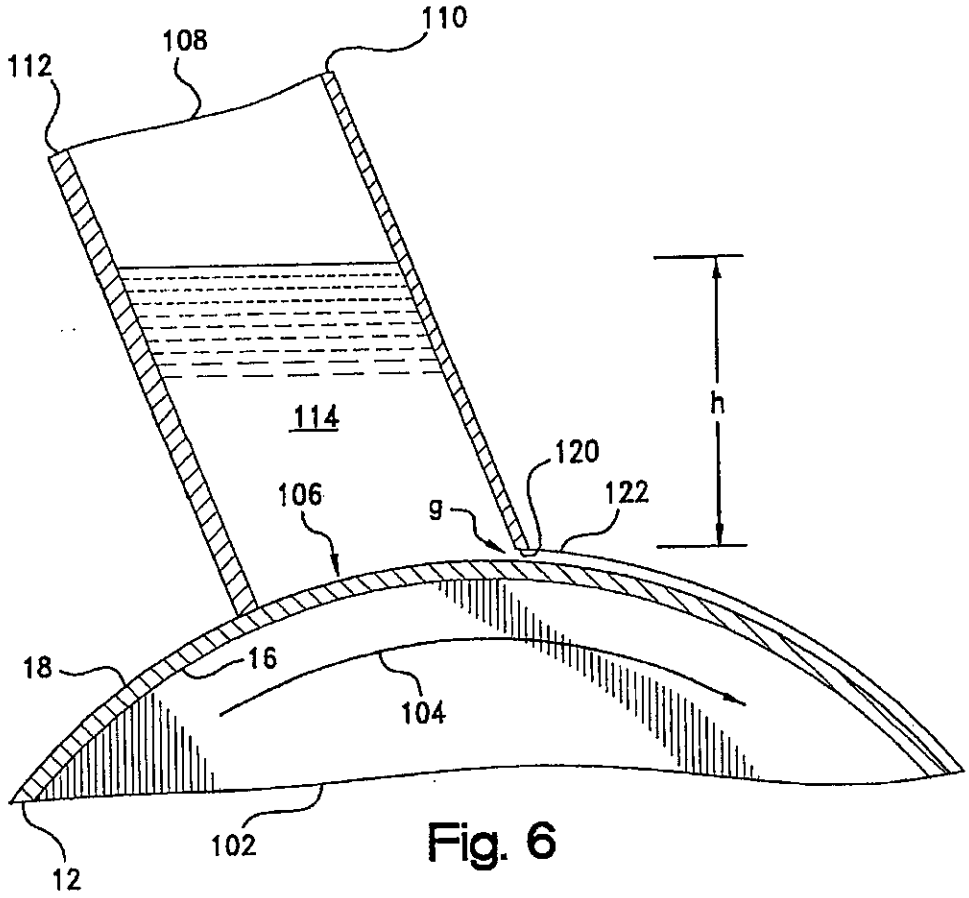


Fig. 6

FLAME RETARDANT EMI SHIELDING GASKET

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. application Ser. No. 09/883,785, filed Jun. 18, 2001, which application is to issue as U.S. Pat. No. 6,387,523; which is a continuation of U.S. application Ser. No. 09/250,338, filed Feb. 16, 1999, now U.S. Pat. No. 6,428,393 and claiming priority to U.S. provisional application Serial No. 60/076,370, filed Feb. 27, 1998, the disclosure of each of which is expressly incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates broadly to electrically-conductive, flame retardant materials for use in electromagnetic interference (EMI) shielding, and to a method of manufacturing the same, and more particularly to an electrically-conductive fabric having a layer of a flame retardant coating applied to one surface thereof for use as a sheathing within an EMI shielding gasket.

The operation of electronic devices including televisions, radios, computers, medical instruments, business machines, communications equipment, and the like is attended by the generation of electromagnetic radiation within the electronic circuitry of the equipment. Such radiation often develops as a field or as transients within the radio frequency band of the electromagnetic spectrum, i.e., between about 10 KHz and 10 GHz, and is termed "electromagnetic interference" or "EMI" as being known to interfere with the operation of other proximate electronic devices.

To attenuate EMI effects, shielding having the capability of absorbing and/or reflecting EMI energy may be employed both to confine the EMI energy within a source device, and to insulate that device or other "target" devices from other source devices. Such shielding is provided as a barrier which is inserted between the source and the other devices, and typically is configured as an electrically conductive and grounded housing which encloses the device. As the circuitry of the device generally must remain accessible for servicing or the like, most housings are provided with openable or removable accesses such as doors, hatches, panels, or covers. Between even the flattest of these accesses and its corresponding mating or faying surface, however, there may be present gaps which reduce the efficiency of the shielding by presenting openings through which radiant energy may leak or otherwise pass into or out of the device. Moreover, such gaps represent discontinuities in the surface and ground conductivity of the housing or other shielding, and may even generate a secondary source of EMI radiation by functioning as a form of slot antenna. In this regard, bulk or surface currents induced within the housing develop voltage gradients across any interface gaps in the shielding, which gaps thereby function as antennas which radiate EMI noise. In general, the amplitude of the noise is proportional to the gap length, with the width of the gap having a less appreciable effect.

For filling gaps within mating surfaces of housings and other EMI shielding structures, gaskets and other seals have been proposed both for maintaining electrical continuity across the structure, and for excluding from the interior of the device such contaminates as moisture and dust. Such seals are bonded or mechanically attached to, or press-fit into, one of the mating surfaces, and function to close any interface gaps to establish a continuous conductive path

thereacross by conforming under an applied pressure to irregularities between the surfaces. Accordingly, seals intended for EMI shielding applications are specified to be of a construction which not only provides electrical surface conductivity even while under compression, but which also has a resiliency allowing the seals to conform to the size of the gap. The seals additionally must be wear resistant, economical to manufacture, and capability of withstanding repeated compression and relaxation cycles. For further information on specifications for EMI shielding gaskets, reference may be had to Severinsen, J., "Gaskets That Block EMI," Machine Design, Vol. 47, No. 19, pp. 74–77 (Aug. 7, 1975).

Requirements for typical EMI shielding applications often dictate a low impedance, low profile gasket which is deflectable under normal closure force loads. Other requirements include low cost and a design which provides an EMI shielding effectiveness for both the proper operation of the device and compliance, in the United States, with commercial Federal Communication Commission (FCC) EMC regulations.

A particularly economical gasket construction, which also requires very low closure forces, i.e. less than about 1 lb/inch (0.175 N/mm), is marketed by the Chomerics Division of Parker-Hannifin Corp., Woburn, Mass. under the tradename "Soft-Shield® 5000 Series." Such construction consists of an electrically-conductive jacket or sheathing which is "cigarette" wrapped lengthwise over a polyurethane or other foam core. As is described further in U.S. Pat. No. 4,871,477, polyurethane foams generally are produced by the reaction of polyisocyanate and a hydroxyl-functional polyol in the presence of a blowing agent. The blowing agent effects the expansion of the polymer structure into a multiplicity of open or closed cells.

The jacket is provided as a highly conductive, i.e., about 1 Ω-sq., nickel-plated-silver, woven rip-stop nylon which is self-terminating when cut. Advantageously, the jacket may be bonded to the core in a continuous molding process wherein the foam is blown or expanded within the jacket as the jacket is wrapped around the expanding foam and the foam and jacket are passed through a die and into a traveling molding. Similar gasket constructions are shown in commonly-assigned U.S. Pat. No. 5,028,739 and in U.S. Pat. Nos. 4,857,668; 5,054,635; 5,105,056; and 5,202,536.

Many electronic devices, including PC's and communication equipment, must not only comply with certain FCC requirements, but also must meet be approved under certain Underwriter's Laboratories (UL) standards for flame retardancy. In this regard, if each of the individual components within an electronic device is UL approved, then the device itself does not require separate approval. Ensuring UL approval for each component therefore reduces the cost of compliance for the manufacturer, and ultimately may result in cheaper goods for the consumer. For EMI shielding gaskets, however, such gaskets must be made flame retardant, i.e., achieving a rating of V-0 under UL Std. No. 94, "Tests for Flammability of Plastic Materials for Parts in Devices and Appliances" (1991), without compromising the electrical conductivity necessary for meeting EMI shielding requirements.

In this regard, and particularly with respect to EMI shielding gaskets of the above-described fabric over foam variety, it has long been recognized that foamed polymeric materials are flammable and, in certain circumstances, may present a fire hazard. Owing to their cellular structure, high organic content, and surface area, most foam materials are

subject to relatively rapid decomposition upon exposure to fire or high temperatures.

One approach for imparting flame retardancy to fabric over foam gaskets has been to employ the sheathing as a flame resistant protective layer for the foam. Indeed, V-0 rating compliance purportedly has been achieved by sheathing the foam within an electrically-conductive Ni/Cu-plated fabric to which a thermoplastic sheet is hot nipped or otherwise fusion bonding to the underside thereof. Such fabrics, which may be further described in one or more of U.S. Pat. Nos. 4,489,126; 4,531,994; 4,608,104; and/or 4,621,013, have been marketed by Monsanto Co., St. Louis, under the tradename "Flectron® Ni/Cu Polyester Taffeta V0."

Other fabric over foam gaskets, as is detailed in U.S. Pat. No. 4,857,668, incorporate a supplemental layer or coating applied to the interior surface of the sheath. Such coating may be a flame-retardant urethane formulation which also promotes the adhesion of the sheath to the foam. The coating additionally may function to reduce bleeding of the foam through the fabric which otherwise could compromise the electrical conductivity of the sheath.

In view of the foregoing, it will be appreciated that further improvements in the design of flame retardant, fabric-over foam EMI shielding gaskets, as well as sheathing materials therefore, would be well-received by the electronics industry. Especially desired would be a flame retardant gasket construction which achieves a UL94 rating of V-0.

BROAD STATEMENT OF THE INVENTION

The present invention is directed to an electrically-conductive, flame retardant material for use in fabric-over-foam EMI shielding gaskets, and to a method of manufacturing the same. In having a layer of a flame retardant coating applied to one side of an electrically-conductive, generally porous fabric, the material of the invention affords UL94 V-0 protection when used as a jacketing in a fabric-over-foam gasket construction. Advantageously, as the flame retardant layer may be wet coated on the fabric without appreciable bleed through, a relatively thin, i.e., 2–4 mil (0.05–0.10 mm), coating layer may be provided on one fabric side without compromising the electrical surface conductivity of the other side. Such a thin coating layer, while being sufficient to provide UL94 V-0 protection, nonetheless maintains the drapability the fabric and thereby facilitates the construction UL94 V-0 compliant gaskets having complex profiles or narrow cross-sections down to about 1 mm.

In a preferred embodiment, the electrically-conductive, flame retardant EMI shielding material of the invention includes a nickel or silver-plated, woven nylon, polyester, or like fabric on one side of which is wet coated a layer of a flame retardant, acrylic latex emulsion or other fluent resin composition. In accordance with the precepts of the method of the invention, the viscosity and hydrodynamic pressure of the emulsion are controlled such that the coating does not penetrate or otherwise "bleed through" the uncoated side of the fabric. The surface conductivity of the opposite side of the fabric therefore is not compromised in EMI shielding applications.

The material of the invention may be employed as a jacket in fabric-over-foam EMI shielding gasket constructions, and is particularly adapted for use in the continuous molding process for such gaskets. As used within such process, the fabric may be wrapped around the foam as a jacket with coated side thereof being disposed as an interior surface

adjacent the foam, and the uncoated side being disposed as an electrically-conductive exterior surface. Advantageously, the coating on the interior surface of the jacket blocks the pores of the fabric to retain the foam therein without penetrate or bleed through to the exterior surface. In being formed of a acrylic material, the coated interior surface of the jacket may function, moreover, depending upon the composition of the foam, as a compatibilizing or "tie" interlayer which promotes the bonding of the foam to the fabric.

The present invention, accordingly, comprises material and method possessing the construction, combination of elements, and arrangement of parts and steps which are exemplified in the detailed disclosure to follow. Advantages of the present invention include a flame retardant yet drapable EMI shielding fabric. Additional advantages include an economical, flame retardant EMI shielding fabric construction wherein a relatively thin layer of a flame retardant coating may be wet coated onto one side of an electrically-conductive, woven or other generally porous EMI shielding fabric without compromising the conductivity of the other side of the fabric. These and other advantages will be readily apparent to those skilled in the art based upon the disclosure contained herein.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIG. 1 is a perspective view of one embodiment of an EMI shielding material according to the present invention which material includes a generally planar fabric member on one side of which is coated a layer of a flame retardant composition, the view being shown with portions being broken away to better reveal the structure of the material;

FIG. 2 is an enlarged cross-sectional view of the EMI shielding material of FIG. 1 taken through plane represented by line 2—2 of FIG. 1;

FIG. 3 is a top view of the material of FIG. 1 which is magnified to reveal the structure of the fabric member thereof;

FIG. 4 is a perspective cross-sectional view of a length of a representative EMI shielding gasket construction according to the present invention including a jacket which is formed of the EMI shielding material of FIG. 1;

FIG. 5 is an end view of the gasket of FIG. 4 which is magnified to reveal the structure thereof; and

FIG. 6 is a schematic, partially cross-sectional view of an illustrative gravity-fed, knife over roll coater as adapted for use in the manufacture of the EMI shielding material of FIG. 1.

The drawings will be described further in connection with the following Detailed Description of the Invention.

DETAILED DESCRIPTION OF THE INVENTION

Certain terminology may be employed in the description to follow for convenience rather than for any limiting purpose. For example, the terms "upper" and "lower" designate directions in the drawings to which reference is made, with the terms "inner" or "interior" and "outer" or "exterior" referring, respectively, to directions toward and away from the center of the referenced element, and the terms "radial" and "axial" referring, respectively, to directions perpendicu-

lar and parallel to the longitudinal central axis of the referenced element. Terminology of similar import other than the words specifically mentioned above likewise is to be considered as being used for purposes of convenience rather than in any limiting sense.

For the illustrative purposes of the discourse to follow, the electromagnetic interference (EMI) shielding material herein involved is described in connection with its use as a flame retardant, electrically-conductive jacket for a foam core, EMI shielding gasket as may be adapted to be received within an interface, such as between a door, panel, hatch, cover, or other parting line of an electromagnetic interference (EMI) shielding structure. The EMI shielding structure may be the conductive housing of a computer, communications equipment, or other electronic device or equipment which generates EMI radiation or is susceptible to the effects thereof. The gasket may be bonded or fastened to, or press-fit into one of a pair of mating surfaces which define the interface within the housing, and functions between the mating surfaces to seal any interface gaps or other irregularities. That is, while under an applied pressure, the gasket resiliently conforms to any such irregularities both to establish a continuous conductive path across the interface, and to environmentally seal the interior of the housing against the ingress of dust, moisture, or other contaminates. It will be appreciated, however, that aspects of the present invention may find utility in other EMI shielding applications. Use within those such other applications therefore should be considered to be expressly within the scope of the present invention.

Referring then to the figures, wherein corresponding reference characters are used to designate corresponding elements throughout the several views, a flame retardant EMI shielding material according to the present invention is shown generally at 10 in FIG. 1 as generally adapted for use as a jacket within for a foam core gasket construction. For purposes of illustration, material sheet **10** is shown to be of indefinite dimensions which may be cut to size for the particular application envisioned. In basic construction, material **10** includes an upper, generally planar and porous fabric member, **12**, and a lower, flame retardant coating member, **14**.

Fabric member has at least an electrically-conductive first side, **16**, and a conductive or non-conductive second side, **18**, defining a thickness dimension, referenced at "t_1" in the cross-sectional view of FIG. **2**, which may vary from about 2–4 mils (0.05–0.10 mm). By "electrically-conductive," it is meant that the fabric may be rendered conductive, i.e., to a surface resistivity of about 0.1 Ω/sq. or less, by reason of its being constructed of electrically-conductive wire, monofilaments, yams or other fibers or, alternatively, by reason of a treatment such as a plating or sputtering being applied to non-conductive fibers to provide an electrically-conductive layer thereon. Preferred electrically-conductive fibers include Monel nickel-copper alloy, silver-plated copper, nickel-clad copper, Ferrex® tin-plated copper-clad steel, aluminum, tin-clad copper, phosphor bronze, carbon, graphite, and conductive polymers. Preferred non-conductive fibers include cotton, wool, silk, cellulose, polyester, polyamide, nylon, and polyimide monofilaments or yarns which are rendered electrically conductive with a metal plating of copper, nickel, silver, nickel-plated-silver, aluminum, tin, or an alloy thereof. As is known, the metal plating may applied to individual fiber strands or to the surfaces of the fabric after weaving, knitting, or other fabrication.

While fabrics such as wire meshes, knits, and non-woven cloths and webs may find application, a preferred fabric construction for member **12** is a plain weave nylon or polyester cloth which is made electrically conductive with between about 20–40% by weight based on the total fabric weight, i.e., 0.01–0.10 g/in^2, of a silver, nickel-silver, or silver-nickel over copper plating. As may be seen in the magnified view of FIG. **1** referenced at **20** in FIG. **3**, such cloth is permeable in having a plain, generally square weave pattern with pores or openings, one of which is referenced at **22**, being defined between the fibers which are represented schematically at **24**. Fibers **24** may be yams, monofilaments or, preferably, bundles of from about 10–20 filaments or threads, each having a diameter of between about 10–50 gm. For example, with fibers **24** each being a bundle of such threads with a thread count of between about 1000–3000 per inch and a weave count of between about 1000–1500 per inch, 1000–2000 openings per inch will be defined with a mean average pore size of between about 0.5–2 mils (12.5–50 μm).

Although a plain, square weave pattern such as a taffeta, tabby, or ripstop is considered preferred, other weaves such as satins, twills, and the like also should be considered within the scope of the invention herein involved. A particularly preferred cloth for fabric member **12** is a 4 mil (0.10 mm) thick, 1.8 oz/yd^2 weight, silver-plated, woven nylon which is marketed commercially under the designation "31EN RIPSTOP" by Swift Textile Metalizing Corp., Bloomfield, Conn. However, depending upon the needs of the specific shielding application, a fabric constructed of a combination or blend of conductive and nonconductive fibers alternatively may be employed. Examples of fabrics woven, braided, or warp knitted from electrically-conductive fibers, or from blends of conductive and non-conductive fibers, are described in Gladfelter, U.S. Pat. No. 4,684,762, and in Buonanno, U.S. Pat. No. 4,857,668.

Returning to FIGS. **1** and **2**, coating member **14** preferably is formed from a curable layer of a fluent, flame retardant resin or other composition which is wet coated onto the second side **18** of fabric member **12**. As is detailed hereinafter, the viscosity and hydrodynamic pressure of the resin composition are controlled in accordance with the precepts of the present invention to delimit the penetration of the resin layer to a depth, referenced at "d" in FIG. **2**, which is less than the thickness dimension t_1 of the fabric member **12**. In this regard, when the layer is cured to form the flame retardant surface coating member **14** on the second side **18** of fabric member **12**, the first side **16** thereof remains electrically-conductive. In a preferred construction, the layer is coated to a wet thickness of about 10 mils (0.25 mm), and then cured to a dried coating or film thickness, referenced at t_2 in FIG. **2**, of between about 2–4 mils (0.05–0.10 mm) at a depth d of about 1–2 mils (0.025–0.05 mm). Ultimately, a total material thickness, referenced at "T," of between about 6–7 mils (0.15–0.20 mm) and a dried weight pickup of between about 100–150 g/yd^2 are observed. By "cured" it is meant that the resin is polymerized, cross-linked, further cross-linked or polymerized, vulcanized, hardened, dried, volatilized, or otherwise chemically or physically changed from a liquid or other fluent form into a solid polymeric or elastomeric phase.

The flame retardant composition preferably is formulated as an aqueous emulsion of an acrylic latex emulsion which is adjusted to a total solids of about 60% and a Brookfield viscosity (#5 spindle, 4 speed) of between about 40,000–60,000 cps, at a density of about 10 lbs per gallon (1.8 g/cm^3). Flame retardancy may be imparted by loading the emulsion with between about 30–50% by weight of one or more conventional flame retardant additives such as aluminum

hydrate, antimony trioxide, phosphate esters, or halogenated compounds such as polybrominated diphenyl oxides. A preferred formulation is a mixture of about 25% by weight, based on the total weight of the emulsion, of decambromodiphenyl oxide and about 15% by weight of one or more antimony compounds. In operation, should the acrylic carrier phase be ignited, the decomposition of the halogenated and metal oxide compounds function to chemically deprive the flame of sufficient oxygen to support combustion. The decomposition of the acrylic phase additionally may lead to the development of a protective, i.e., thermally-insulative or refractory, outer char layer.

A preferred flame retardant, acrylic latex emulsion is marketed commercially by Heveatex Corp., Fall River, Mass., under the designation "4129FR." The viscosity of the emulsion may be adjusted to between about 40,000–60,000 cps using an aqueous acryloid gel or other acrylic thickener. In this regard, the increased viscosity of the emulsion contributes to delimiting the penetration of the coating layer into the fabric member. However, as this relatively high viscosity may lead to undesirable porosity in the dried film, the emulsion additionally may be modified to reduce air entrapment and bubble formation in the coating layer with up to about 1% by weight of one or more commercial surfactants such as "Bubble Breaker" by Witco Chemical Corp. (Chicago, Ill.) and "Foam Master Antifoam" by Diamond Shamrock, Inc. (San Antonio, Tex.).

As aforementioned, EMI shielding material **10** of the present invention is particularly adapted for use as a flame retardant, electrically-conductive jacket which is provided over a foam core in an EMI shielding gasket construction such as gasket **50** of FIG. **4**. In a representative embodiment, gasket **50** includes an elongate, resilient foam core member, **52**, which may be of an indefinite length. Core member **52** has an outer circumferential surface, **54**, defining the cross-sectional profile of gasket **50** which, for illustrative purposes, is of a generally polygonal, i.e., square or rectangular geometry. Other plane profiles, such as circular, semicircular, or elliptical, or complex profiles may be substituted, however, depending upon the geometry of the interface to be sealed. Core member **12** may be of any radial or diametric extent, but for most applications will have a diametric extent or width of from about 0.25 inch (0.64 cm) to 1 inch (2.54 cm).

For affording gap-filling capabilities, it is preferred that core member **52** is provided to be complaint over a wide range of temperatures, and to exhibit good compression-relaxation hysteresis even after repeated cyclings or long compressive dwells. Core member **52** therefore may be formed of a foamed elastomeric thermoplastic such as a polyethylene, polypropylene, polypropylene-EPDM blend, butadiene, styrene-butadiene, nitrile, chlorosulfonate, or a foamed neoprene, urethane, or silicone. Preferred materials of construction include open or closed cell urethanes or blends such as a polyolefin resin/monoolefin copolymer blend, or a neoprene, silicone, or nitrile sponge rubber.

Core member **52** may be provided as an extruded or molded foam profile over which shielding material **10** is wrapped as a sheathed, with the edges of sheathed being overlapped as at **56**. In a preferred construction, shielding material **10** is bonded to the core member **52** in a continuous molding process wherein the foam is blown or expanded within the shielding material. As may be seen best with reference to the magnified view of FIG. **4** referenced at **60** in FIG. **5**, in such construction coating member **14** is disposed adjacent core member **52** as an interior surface, **62**, of shielding member **10**, with the uncoated side **16** of fabric member **12** being oppositely disposed as an electrically-conductive exterior surface, **64**, of the gasket **50**. It will be appreciated that the coated interior surface **62** blocks the pores **22** (FIG. **3**) of the fabric member **12** of the fabric to retain the blown foam therein without penetrate or bleed through to the exterior gasket surface **64**. Depending upon the respective compositions of the foam and coating, the interior surface **62** may function, moreover, as a compatibilizing or "tie" interlayer which promotes the bonding of the foam to the fabric. Gasket construction **50** advantageously provides a structure that may be used in very low closure force, i.e. less than about 1 lb/inch (0.175 N/mm), applications.

Referring again to FIG. **4**, an adhesive layer, **70**, may be applied along the lengthwise extent of gasket **50** to the underside of exterior surface **64** for the attachment of the gasket to a substrate. Such layer **70** preferably is formulated to be of a pressure sensitive adhesive (PSA) variety. As is described in U.S. Pat. No. 4,988,550, suitable PSA's for EMI shielding applications include formulations based on silicones, neoprene, styrene butadiene copolymers, acrylics, acrylates, polyvinyl ethers, polyvinyl acetate copolymers, polyisobutylenes, and mixtures, blends, and copolymers thereof. Acrylic-based formulations, however, generally are considered to be preferred for the EMI applications of the type herein involved. Although PSA's are preferred for adhesive layer **70**, other adhesives such as epoxies and urethanes may be substituted and, accordingly, are to be considered within the scope of the present invention. Heat-fusible adhesives such a hot-melts and thermoplastic films additionally may find applicability.

Inasmuch as the bulk conductivity of gasket **50** is determined substantially through its surface contact with the substrate, an electrically-conductive PSA may be preferred to ensure optimal EMI shielding performance. Such adhesives conventionally are formulated as containing about 1–25% by weight of a conductive filler to yield a volume resistivity of from about 0.01–0.001 Ω-cm. The filler may be incorporated in the form of particles, fibers, flakes, microspheres, or microballoons, and may range in size of from about 1–100 microns. Typically filler materials include inherently conductive material such as metals, carbon, and graphite, or nonconductive materials such as plastic or glass having a plating of a conductive material such as a noble metal or the like. In this regard, the means by which the adhesive is rendered electrically conductive is not considered to be a critical aspect of the present invention, such that any means achieving the desired conductivity and adhesion are to be considered suitable.

For protecting the outer portion of adhesive layer **70** which is exposed on the exterior surface of the gasket, a release sheets, shown at **72**, may be provided as removably attached to the exposed adhesive. As is common in the adhesive art, release sheet **72** may be provided as strip of a waxed, siliconized, or other coated paper or plastic sheet or the like having a relatively low surface energy so as to be removable without appreciable lifting of the adhesive from the exterior surface **64**..

In the production of commercial quantities of the EMI shielding material **10** of the present invention, the viscosity adjusted and otherwise modified acrylic latex emulsion or other resin composition may be coated and cured on one side the fabric member **12** by a direct wet process such as knife over roll or slot die. With whatever process is employed, the hydrodynamic pressure of the resin composition is controlled in accordance with the precepts of the present invention to delimit the penetration of the resin layer to a depth

which is less than the thickness dimension of the fabric member. For example, and with reference to FIG. **6** wherein the head of a representative gravity-fed knife over roll coater is shown somewhat schematically at **100**, porous, i.e., permeable, fabric member **12** is conveyed from a feed roll or the like (not shown) over a nip roller, **102**, which rotates in the direction referenced by arrow **104**. With the first side **16** of fabric member **12** supported on roller **102**, the fabric second side **18** is passed beneath the opening, referenced at **106**, of a coating trough, **108**. Trough **108** is defined by a front plate, **110**, a back plate, **112**, and a pair of side plates (not shown).

The emulsion or other fluent resin composition, referenced at **114**, is pumped or otherwise transported into trough **108** which is filled to a fluid level, referenced at h. For a given fluid density, this level h is controlled such that the hydrodynamic pressure at the fabric-liquid interface is maintained within preset limits. For example, with a fluid density of about 10 pounds per gallon (1.8 g/cm^3), and a fabric having a porosity of about 1000–2000 openings per inch with a mean average pore size of between about 0.5–2 mils (12.5–50 μm), the fluid level H is controlled at about 4 inches (10 cm) to yield a hydrodynamic pressure of about 0.05 psi (0.35 kPa) at the fabric-liquid interface. For other coating processes, the hydrodynamic fluid pressure may be controlled, for example, by a pumping pressure or the like.

In the illustrative knife-over-roll coating process, the lower edge, **120**, of front plate **110** defines a knife surface which is shimmed or otherwise spaced-apart a predetermined distance from the second side **18** of fabric member **12**. Such spacing provides a clearance or gap, referenced at "g," of typically about 10 mils (0.25 mm), but which is adjustable to regulate the thickness of the liquid coating layer, **122**, being applied to the fabric member. From roller **104**, the coated fabric member **12** may be conveyed via a take-up roller arrangement (not shown) through a in-line oven or the like to dry or flash the water or other diluent in the liquid coating layer **122**, or to otherwise cure the liquid coating layer **122** in developing an adherent, tack-free, film or other layer of coating member **14** (FIG. 1) on the single side **18** of fabric member **12**.

The Example to follow, wherein all percentages and proportions are by weight unless otherwise expressly indicated, is illustrative of the practicing of the invention herein involved, but should not be construed in any limiting sense.

EXAMPLE

Representative EMI shielding materials according to the present invention were constructed for characterization. In this regard, a master batch of a flame retardant coating composition was compounded using an acrylic latex emulsion (Heveatex "4129FR"). The viscosity of the emulsion was adjusted to a Brookfield viscosity (#4 spindle, 40 speed) of about 60,000 cps with about 5 wt % of an acryloid thickener (Acrysol™ GS, Monsanto Co., St. Louis, Mo.). The modified emulsion had a total solids content of about 60% by weight, a density of about 10 pounds per gallon (1.8 g/cm^3), and a pH of between about 7.5 and 9.5.

The emulsion was applied using a knife over roll coater (JETZONE Model 7319, Wolverine Corp., Merrimac, Mass.) to one side of a silver-plated nylon fabric (Swift "31EN RIPSTOP") having a thickness of about 4 mils (0.1 mm). With the fluid level in the coating trough of the coater maintained at about 4 inch (10 cm), the emulsion was delivered to the surface of the cloth at a hydrodynamic pressure of about 0.05 psi (0.35 kPa). The coating knife was shimmed to a 10 mil (0.25 mm) gap above the fabric to yield a wet coating draw down thickness of about 10 mils. Following an oven curing at 100–125° C. for 5 minutes, a dried coating or film thickness of about 2.5 mils (0.635 mm) was obtained with a weight pickup of about 130–145 g/yd^2 and a total material thickness of between about 6–7 mils (0.15–0.18 mm). An inspection of the coated fabric cloth revealed a coating penetration depth of about 1–2 mils (0.02–0.05 mm) providing acceptable mechanical retention and/or adhesion of the coating onto the fabric surface. The opposite side of the fabric, however, was observed to be substantially coating free, and to retain a surface resistivity of about 0.1 Ω/sq for unaffected EMI shielding effectiveness.

Fabric samples similarly coated in the manner described were subjected to an in-house vertical flame test. No burning was observed at dried film thickness of 2, 3, or 4 mils (0.05, 0.08, 0.10 mm). Accordingly, a reasonable operating window of film thickness was suggested for production runs.

Samples also were provided, as jacketed over a polyurethane foam core in an EMI shielding gasket construction, for flame testing by Underwriters Laboratories, Inc., Melville, N.Y. A flame class rating of V-0 under UL94 was assigned at a minimum thickness of 1.0 mm. The gasket construction therefore was found to be compliant with the applicable UL requirements, and was approved to bear the "UL" certification mark.

The foregoing results confirm that the EMI shielding material of the present invention affords UL94 V-0 protection when used as a jacketing in a fabric-over-foam gasket construction. Unexpectedly, it was found that a relatively porous or permeable fabric may be wet coated on one side with a relatively thin, i.e., 2–4 mil (0.05–0.10 mm), coating layer of a flame retardant composition without compromising the electrical surface conductivity of the other side. Such a thin coating layer, while being sufficient to provide UL94 V-0 protection in a conventional fabric-over-foam gasket construction, nonetheless maintains the drapability the fabric and thereby facilitates the fabrication of UL94 V-0 compliant gaskets having complex profiles or narrow cross-sections down to about 1 mm.

As it is anticipated that certain changes may be made in the present invention without departing from the precepts herein involved, it is intended that all matter contained in the foregoing description shall be interpreted as illustrative and not in a limiting sense. All references cited herein are expressly incorporated by reference.

What is claimed is:

1. A flame retardant, electromagnetic interference (EMI) shielding gasket comprising:

a resilient core member which is not V-0 rated under Underwriter's Laboratories (UL) Standard No. 94 extending lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis, said core member being formed of a foamed elastomeric material;

an electrically-conductive fabric member surrounding the outer surface of said core member, said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface, at least the exterior surface being electrically-conductive and the exterior surface defining with the interior surface a thickness dimension of the fabric member therebetween; and

a flame retardant layer coating at least a portion of the interior surface of said fabric member, said flame

retardant layer being effective to afford said gasket a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94 and penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive.

2. The gasket of claim 1 wherein said flame retardant layer has a thickness of between about 2–4 mils (0.05–0.10 mm).

3. The gasket of claim 1 wherein said flame retardant layer is formed as a cured film of a flame retardant acrylic latex emulsion.

4. The gasket of claim 1 wherein said fabric member is a metal-plated cloth.

5. The gasket of claim 4 wherein said cloth comprises fibers selected from the group consisting of cotton, wool, silk, cellulose, polyester, polyamide, nylon, and combinations thereof, and said metal is selected from the group consisting of copper, nickel, silver, nickel-plated-silver, aluminum, tin, and combinations thereof.

6. The gasket of claim 1 wherein said foamed elastomeric material is selected from the group consisting of polyethylenes, polypropylenes, polypropylene-EPDM blends, butadienes, styrene-butadienes, nitriles, chlorosulfonates, neoprenes, urethanes, silicones, and polyolefin resin/monoolefin copolymer blends, and combinations thereof.

7. The gasket of claim 1 wherein said fabric member has a thickness of between about 2–4 mils (0.05–0.10 mm).

8. A flame retardant, electromagnetic interference (EMI) shielding gasket comprising:

a resilient core member extending lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis, said core member being formed of a foamed elastomeric material;

an electrically-conductive fabric member surrounding the outer surface of said core member, said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface, at least the exterior surface being electrically-conductive and the exterior surface defining with the interior surface a thickness dimension of the fabric member therebetween; and

a flame retardant layer coating at least a portion of the interior surface of said fabric member, said flame retardant layer comprising between about 30–50% by weight of one or more flame retardant additives and penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive.

9. The gasket of claim 8 wherein said flame retardant layer has a thickness of between about 2–4 mils (0.05–0.10 mm).

10. The gasket of claim 8 wherein said flame retardant layer is formed as a cured film of a flame retardant acrylic latex emulsion.

11. The gasket of claim 8 wherein said fabric member is a metal-plated cloth.

12. The gasket of claim 11 wherein said cloth comprises fibers selected from the group consisting of cotton, wool, silk, cellulose, polyester, polyamide, nylon, and combinations thereof, and said metal is selected from the group consisting of copper, nickel, silver, nickel-plated-silver, aluminum, tin, and combinations thereof.

13. The gasket of claim 8 wherein said foamed elastomeric material is selected from the group consisting of polyethylenes, polypropylenes, polypropylene-EPDM blends, butadienes, styrene-butadienes, nitriles, chlorosulfonates, neoprenes, urethanes, silicones, and polyolefin resin/monoolefin copolymer blends, and combinations thereof.

14. The gasket of claim 8 wherein said fabric member has a thickness of between about 2–4 mils (0.05–0.10 mm).

15. The gasket of claim 8 wherein said flame retardant layer is effective to afford the gasket a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94.

16. The gasket of claim 15 wherein said core member is not V-0 rated under Underwriter's Laboratories (UL) Standard No. 94.

17. The gasket of claim 8 wherein said core member is not V-0 rated under Underwriter's Laboratories (UL) Standard No. 94.

18. The gasket of claim 8 wherein said one or more flame retardant additives are selected from the group consisting of aluminum hydrate, antimony trioxide, phosphate esters, and halogenated compounds.

* * * * *

EXHIBIT B

EXHIBIT B

(12) **United States Patent**
Bunyan et al.

(10) **Patent No.: US 6,716,536 B2**
(45) **Date of Patent: *Apr. 6, 2004**

(54) **FLAME RETARDANT EMI SHIELDING GASKET**

(75) Inventors: **Michael H. Bunyan**, Chelmsford, MA (US); **William I. Flanders**, Merimack, NH (US)

(73) Assignee: **Parker-Hannifin Corporation**, Cleveland, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/318,609**

(22) Filed: **Dec. 11, 2002**

(65) **Prior Publication Data**

US 2003/0124934 A1 Jul. 3, 2003

Related U.S. Application Data

(63) Continuation of application No. 10/142,803, filed on May 9, 2002, now Pat. No. 6,521,348, which is a continuation of application No. 09/883,785, filed on Jun. 18, 2001, now Pat. No. 6,387,523, which is a continuation of application No. 09/250,338, filed on Feb. 16, 1999, now Pat. No. 6,248,393.

(60) Provisional application No. 60/076,370, filed on Feb. 27, 1998.

(51) **Int. Cl.**[7] **B32B 5/14**; B32B 5/18; H05K 9/00

(52) **U.S. Cl.** **428/457**; 361/818

(58) **Field of Search** 428/457; 361/818

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,178,410	A	12/1979	Tomita
4,396,661	A	8/1983	George et al.
4,447,484	A	5/1984	Slosberg et al.
4,489,126	A	12/1984	Holtrop et al.
4,531,994	A	7/1985	Holtrop et al.
4,540,617	A	9/1985	Kawanishi et al.

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

DE	9013936	12/1990
FR	2308030	11/1976
JP	07-176889	* 7/1995
WO	0326441	8/1989

OTHER PUBLICATIONS

Kleiner, J. Vinyl Technol. vol 4 No. 4, Dec. 1982, pp 157–159.*

Dye, James M. Compliance Engineering 17(3), pp 138 and 140–145, 2000.*

Copy of International Search Report for PCT Case No. PCT/US99/04100, Jan. 7, 1999.

Chomerics Parker Hannifin Seals Catalog dated 1997 for Soft-Shield Low Closure Force EMI Gaskets.

Monsanto Flectron Metalized Materials dated Sep. 12, 1995.

Copy of the International Application Published Under the Patent Cooperation Treaty in International Patent Application No. PCT/US00/20609 (WO 01/10182) entitled: "Method and Apparatus for Manufacturing A Flame Retardant EMI Gasket" Feb. 2001.

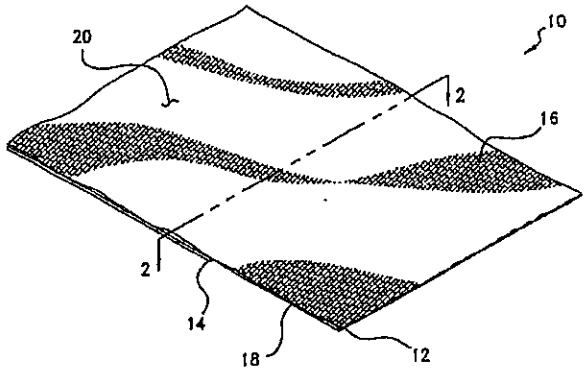
Underwriters Laboratories, Inc. letter dated Sep. 20, 1995.

Primary Examiner—Erma Cameron
(74) *Attorney, Agent, or Firm*—John A. Molnar, Jr.

(57) **ABSTRACT**

A flame retardant, electromagnetic interference (EMI) shielding gasket construction. The construction includes a resilient core member formed of a foamed elastomeric material, an electrically-conductive fabric member surrounding the outer surface of the core member, and a flame retardant layer coating at least a portion of the interior surface of the fabric member. The flame retardant layer is effective to afford the gasket construction with a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94.

9 Claims, 3 Drawing Sheets



U.S. PATENT DOCUMENTS

4,569,304	A		2/1986	Le Maitre
4,572,960	A		2/1986	Ebneth et al.
4,608,104	A		8/1986	Holtrop et al.
4,621,013	A		11/1986	Holtrop et al.
4,666,765	A		5/1987	Caldwell et al.
4,684,762	A		8/1987	Gladfelter
4,753,840	A		6/1988	Van Gompel
4,797,171	A		1/1989	Van Gompel
4,857,668	A		8/1989	Buonanno
4,871,477	A		10/1989	Dimanshteyn
4,988,550	A		1/1991	Keyser et al.
5,009,927	A		4/1991	Cloyd et al.
5,028,739	A		7/1991	Keyser et al.
5,045,635	A		9/1991	Kaplo et al.
5,089,325	A		2/1992	Covey
5,105,056	A		4/1992	Hoge, Jr. et al.
5,122,411	A		6/1992	Iwamoto et al.
5,202,536	A		4/1993	Buonanno
5,204,403	A		4/1993	Furuta et al.
5,266,354	A		11/1993	Tohyama et al.
5,612,092	A		3/1997	Strenger et al.
5,614,306	A		3/1997	Jobe et al.
5,635,252	A		6/1997	Fraser, Jr. et al.
5,641,438	A	*	6/1997	Bunyan et al. 264/40.3
5,641,544	A		6/1997	Melancon et al.
5,674,606	A		10/1997	Powers, Jr.
5,700,532	A		12/1997	Chiou

* cited by examiner

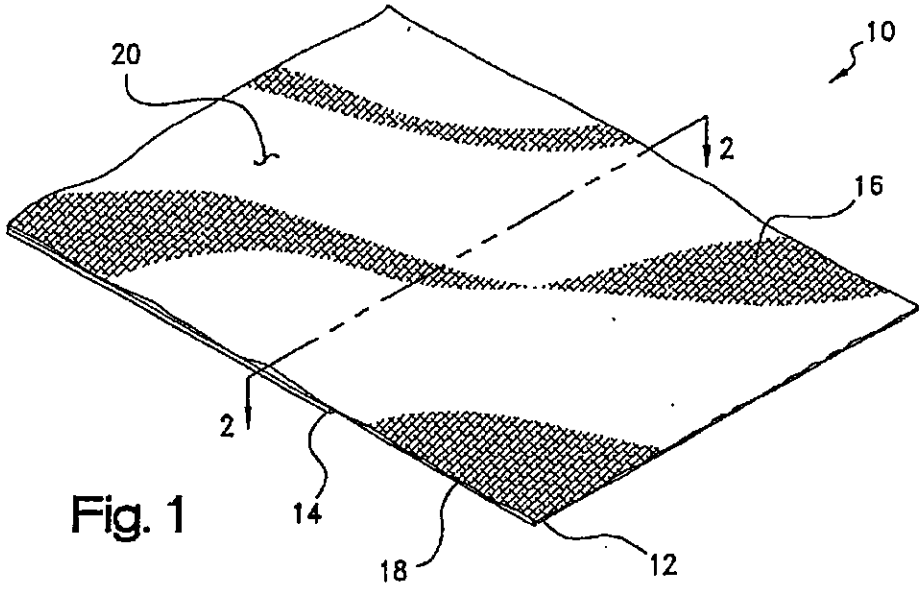


Fig. 1

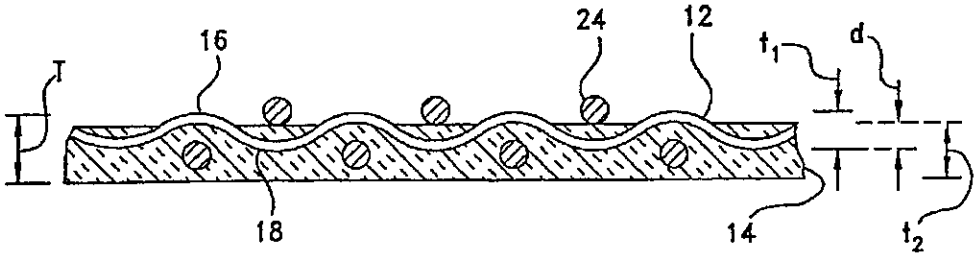


Fig. 2

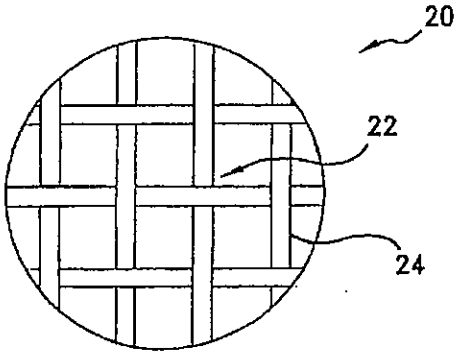


Fig. 3

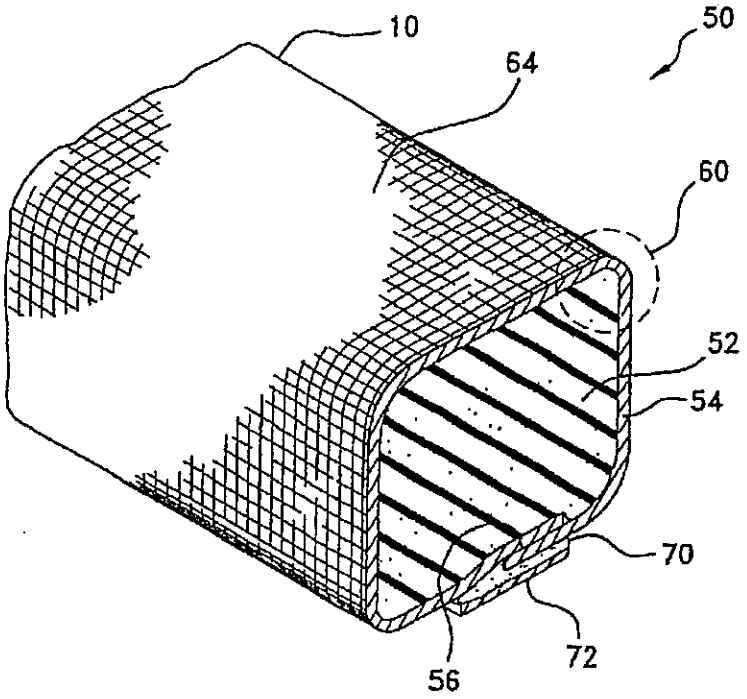


Fig. 4

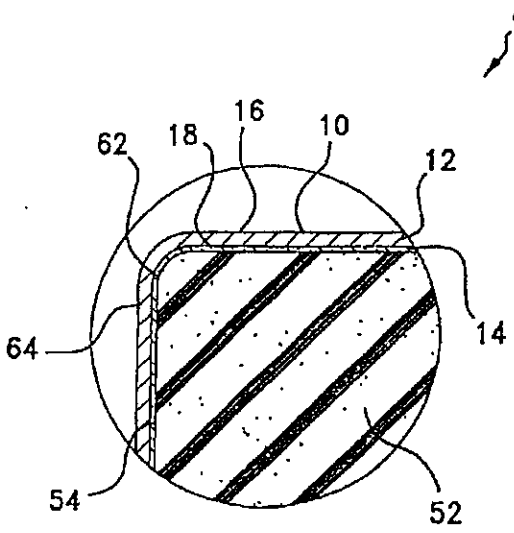


Fig. 5

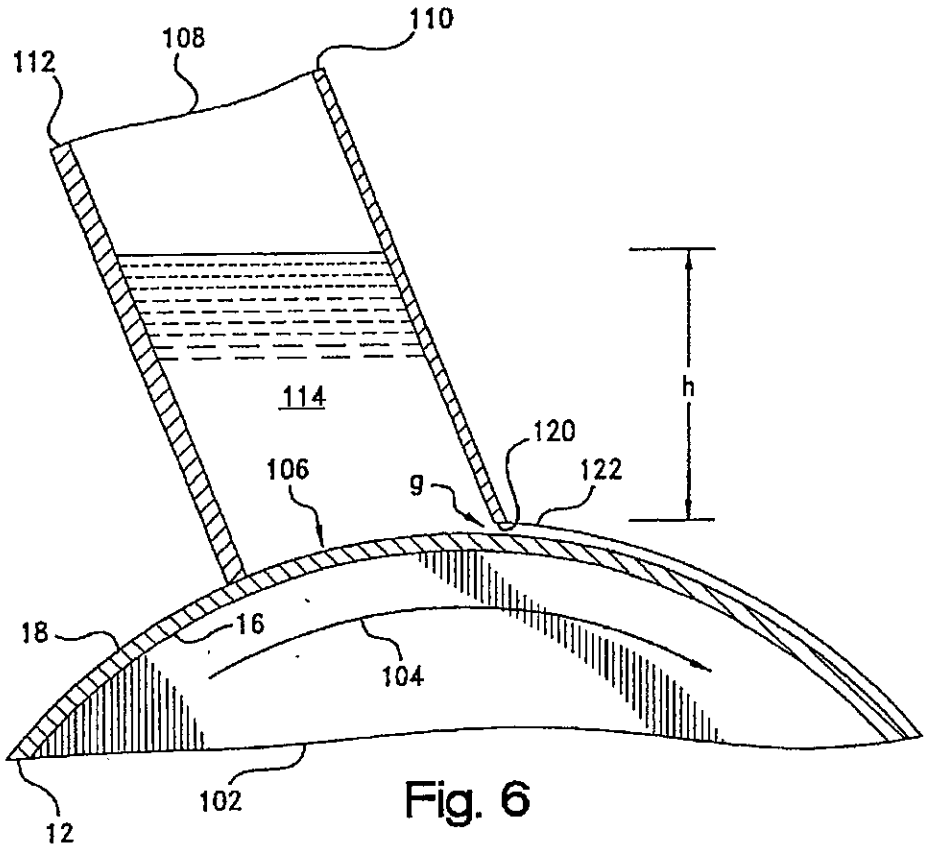


Fig. 6

FLAME RETARDANT EMI SHIELDING GASKET

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. application Ser. No. 10/142,803 filed May 9, 2002, now U.S. Pat. No. 6,521,348, which is a continuation of U.S. application Ser. No. 09/883,785, filed Jun. 18, 2001, now U.S. Pat. No. 6,387,523; which is a continuation of U.S. application Ser. No. 09/250,338, filed Feb. 16, 1999, now U.S. Pat. No. 6,248,393 and claiming priority to U.S. provisional application Ser. No. 60/076,370, filed Feb. 27, 1998, the disclosure of each of which is expressly incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates broadly to electrically-conductive, flame retardant materials for use in electromagnetic interference (EMI) shielding, and to a method of manufacturing the same, and more particularly to an electrically-conductive fabric having a layer of a flame retardant coating applied to one surface thereof for use as a sheathing within an EMI shielding gasket.

The operation of electronic devices including televisions, radios, computers, medical instruments, business machines, communications equipment, and the like is attended by the generation of electromagnetic radiation within the electronic circuitry of the equipment. Such radiation often develops as a field or as transients within the radio frequency band of the electromagnetic spectrum, i.e., between about 10 KHz and 10 GHz, and is termed "electromagnetic interference" or "EMI" as being known to interfere with the operation of other proximate electronic devices.

To attenuate EMI effects, shielding having the capability of absorbing and/or reflecting EMI energy may be employed both to confine the EMI energy within a source device, and to insulate that device or other "target" devices from other source devices. Such shielding is provided as a barrier which is inserted between the source and the other devices, and typically is configured as an electrically conductive and grounded housing which encloses the device. As the circuitry of the device generally must remain accessible for servicing or the like, most housings are provided with openable or removable accesses such as doors, hatches, panels, or covers. Between even the flattest of these accesses and its corresponding mating or faying surface, however, there may be present gaps which reduce the efficiency of the shielding by presenting openings through which radiant energy may leak or otherwise pass into or out of the device. Moreover, such gaps represent discontinuities in the surface and ground conductivity of the housing or other shielding, and may even generate a secondary source of EMI radiation by functioning as a form of slot antenna. In this regard, bulk or surface currents induced within the housing develop voltage gradients across any interface gaps in the shielding, which gaps thereby function as antennas which radiate EMI noise. In general, the amplitude of the noise is proportional to the gap length, with the width of the gap having a less appreciable effect.

For filling gaps within mating surfaces of housings and other EMI shielding structures, gaskets and other seals have been proposed both for maintaining electrical continuity across the structure, and for excluding from the interior of the device such contaminates as moisture and dust. Such seals are bonded or mechanically attached to, or press-fit into, one of the mating surfaces, and function to close any interface gaps to establish a continuous conductive path thereacross by conforming under an applied pressure to irregularities between the surfaces. Accordingly, seals intended for EMI shielding applications are specified to be of a construction which not only provides electrical surface conductivity even while under compression, but which also has a resiliency allowing the seals to conform to the size of the gap. The seals additionally must be wear resistant, economical to manufacture, and capability of withstanding repeated compression and relaxation cycles. For further information on specifications for EMI shielding gaskets, reference may be had to Severinsen, J., "Gaskets That Block EMI," Machine Design, Vol. 47, No. 19, pp. 74–77 (Aug. 7, 1975).

Requirements for typical EMI shielding applications often dictate a low impedance, low profile gasket which is deflectable under normal closure force loads. Other requirements include low cost and a design which provides an EMI shielding effectiveness for both the proper operation of the device and compliance, in the United States, with commercial Federal Communication Commission (FCC) EMC regulations.

A particularly economical gasket construction, which also requires very low closure forces, i.e. less than about 1 lb/inch (0.175 N/mm), is marketed by the Chomerics Division of Parker-Hannifin Corp., Woburn, Mass. under the tradename "Soft-Shield® 5000 Series." Such construction consists of an electrically-conductive jacket or sheathing which is "cigarette" wrapped lengthwise over a polyurethane or other foam core. As is described further in U.S. Pat. No. 4,871,477, polyurethane foams generally are produced by the reaction of polyisocyanate and a hydroxyl-functional polyol in the presence of a blowing agent. The blowing agent effects the expansion of the polymer structure into a multiplicity of open or closed cells.

The jacket is provided as a highly conductive, i.e., about 1 Ω-sq., nickel-plated-silver, woven rip-stop nylon which is self-terminating when cut. Advantageously, the jacket may be bonded to the core in a continuous molding process wherein the foam is blown or expanded within the jacket as the jacket is wrapped around the expanding foam and the foam and jacket are passed through a die and into a traveling molding. Similar gasket constructions are shown in commonly-assigned U.S. Pat. No. 5,028,739 and in U.S. Pat. Nos. 4,857,668; 5,054,635; 5,105,056; and 5,202,536.

Many electronic devices, including PC's and communication equipment, must not only comply with certain FCC requirements, but also must meet be approved under certain Underwriter's Laboratories (UL) standards for flame retardancy. In this regard, if each of the individual components within an electronic device is UL approved, then the device itself does not require separate approval. Ensuring UL approval for each component therefore reduces the cost of compliance for the manufacturer, and ultimately may result in cheaper goods for the consumer. For EMI shielding gaskets, however, such gaskets must be made flame retardant, i.e., achieving a rating of V-0 under UL Std. No. 94, "Tests for Flammability of Plastic Materials for Parts in Devices and Appliances" (1991), without compromising the electrical conductivity necessary for meeting EMI shielding requirements.

In this regard, and particularly with respect to EMI shielding gaskets of the above-described fabric over foam variety, it has long been recognized that foamed polymeric materials are flammable and, in certain circumstances, may

present a fire hazard. Owing to their cellular structure, high organic content, and surface area, most foam materials are subject to relatively rapid decomposition upon exposure to fire or high temperatures.

One approach for imparting flame retardancy to fabric over foam gaskets has been to employ the sheathing as a flame resistant protective layer for the foam. Indeed, V-0 rating compliance purportedly has been achieved by sheathing the foam within an electrically-conductive Ni/Cu-plated fabric to which a thermoplastic sheet is hot nipped or otherwise fusion bonding to the underside thereof. Such fabrics, which may be further described in one or more of U.S. Pat. Nos. 4,489,126; 4,531,994; 4,608,104; and/or 4,621,013, have been marketed by Monsanto Co., St. Louis, under the tradename "Flectron® Ni/Cu Polyester Taffeta V0."

Other fabric over foam gaskets, as is detailed in U.S. Pat. No. 4,857,668, incorporate a supplemental layer or coating applied to the interior surface of the sheath. Such coating may be a flame-retardant urethane formulation which also promotes the adhesion of the sheath to the foam. The coating additionally may function to reduce bleeding of the foam through the fabric which otherwise could compromise the electrical conductivity of the sheath.

In view of the foregoing, it will be appreciated that further improvements in the design of flame retardant, fabric-over foam EMI shielding gaskets, as well as sheathing materials therefore, would be well-received by the electronics industry. Especially desired would be a flame retardant gasket construction which achieves a UL94 rating of V-0.

BROAD STATEMENT OF THE INVENTION

The present invention is directed to an electrically-conductive, flame retardant material for use in fabric-over-foam EMI shielding gaskets, and to a method of manufacturing the same. In having a layer of a flame retardant coating applied to one side of an electrically-conductive, generally porous fabric, the material of the invention affords UL94 V-0 protection when used as a jacketing in a fabric-over-foam gasket construction. Advantageously, as the flame retardant layer may be wet coated on the fabric without appreciable bleed through, a relatively thin, i.e., 2–4 mil (0.05–0.10 mm), coating layer may be provided on one fabric side without compromising the electrical surface conductivity of the other side. Such a thin coating layer, while being sufficient to provide UL94 V-0 protection, nonetheless maintains the drapability the fabric and thereby facilitates the construction UL94 V-0 compliant gaskets having complex profiles or narrow cross-sections down to about 1 mm.

In a preferred embodiment, the electrically-conductive, flame retardant EMI shielding material of the invention includes a nickel or silver-plated, woven nylon, polyester, or like fabric on one side of which is wet coated a layer of a flame retardant, acrylic latex emulsion or other fluent resin composition. In accordance with the precepts of the method of the invention, the viscosity and hydrodynamic pressure of the emulsion are controlled such that the coating does not penetrate or otherwise "bleed through" the uncoated side of the fabric. The surface conductivity of the opposite side of the fabric therefore is not compromised in EMI shielding applications.

The material of the invention may be employed as a jacket in fabric-over-foam EMI shielding gasket constructions, and is particularly adapted for use in the continuous molding process for such gaskets. As used within such process, the fabric may be wrapped around the foam as a jacket with coated side thereof being disposed as an interior surface adjacent the foam, and the uncoated side being disposed as an electrically-conductive exterior surface. Advantageously, the coating on the interior surface of the jacket blocks the pores of the fabric to retain the foam therein without penetrate or bleed through to the exterior surface. In being formed of a acrylic material, the coated interior surface of the jacket may function, moreover, depending upon the composition of the foam, as a compatibilizing or "tie" interlayer which promotes the bonding of the foam to the fabric.

The present invention, accordingly, comprises material and method possessing the construction, combination of elements, and arrangement of parts and steps which are exemplified in the detailed disclosure to follow. Advantages of the present invention include a flame retardant yet drapable EMI shielding fabric. Additional advantages include an economical, flame retardant EMI shielding fabric construction wherein a relatively thin layer of a flame retardant coating may be wet coated onto one side of an electrically-conductive, woven or other generally porous EMI shielding fabric without compromising the conductivity of the other side of the fabric. These and other advantages will be readily apparent to those skilled in the art based upon the disclosure contained herein.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIG. 1 is a perspective view of one embodiment of an EMI shielding material according to the present invention which material includes a generally planar fabric member on one side of which is coated a layer of a flame retardant composition, the view being shown with portions being broken away to better reveal the structure of the material;

FIG. 2 is an enlarged cross-sectional view of the EMI shielding material of FIG. 1 taken through plane represented by line 2—2 of FIG. 1;

FIG. 3 is a top view of the material of FIG. 1 which is magnified to reveal the structure of the fabric member thereof;

FIG. 4 is a perspective cross-sectional view of a length of a representative EMI shielding gasket construction according to the present invention including a jacket which is formed of the EMI shielding material of FIG. 1;

FIG. 5 is an end view of the gasket of FIG. 4 which is magnified to reveal the structure thereof, and

FIG. 6 is a schematic, partially cross-sectional view of an illustrative gravity-fed, knife over roll coater as adapted for use in the manufacture of the EMI shielding material of FIG. 1.

The drawings will be described further in connection with the following Detailed Description of the Invention.

DETAILED DESCRIPTION OF THE INVENTION

Certain terminology may be employed in the description to follow for convenience rather than for any limiting purpose. For example, the terms "upper" and "lower" designate directions in the drawings to which reference is made, with the terms "inner" or "interior" and "outer" or "exterior" referring, respectively, to directions toward and away from

the center of the referenced element, and the terms "radial" and "axial" referring, respectively, to directions perpendicular and parallel to the longitudinal central axis of the referenced element. Terminology of similar import other than the words specifically mentioned above likewise is to be considered as being used for purposes of convenience rather than in any limiting sense.

For the illustrative purposes of the discourse to follow, the electromagnetic interference (EMI) shielding material herein involved is described in connection with its use as a flame retardant, electrically-conductive jacket for a foam core, EMI shielding gasket as may be adapted to be received within an interface, such as between a door, panel, hatch, cover, or other parting line of an electromagnetic interference (EMI) shielding structure. The EMI shielding structure may be the conductive housing of a computer, communications equipment, or other electronic device or equipment which generates EMI radiation or is susceptible to the effects thereof. The gasket may be bonded or fastened to, or press-fit into one of a pair of mating surfaces which define the interface within the housing, and functions between the mating surfaces to seal any interface gaps or other irregularities. That is, while under an applied pressure, the gasket resiliently conforms to any such irregularities both to establish a continuous conductive path across the interface, and to environmentally seal the interior of the housing against the ingress of dust, moisture, or other contaminates. It will be appreciated, however, that aspects of the present invention may find utility in other EMI shielding applications. Use within those such other applications therefore should be considered to be expressly within the scope of the present invention.

Referring then to the figures, wherein corresponding reference characters are used to designate corresponding elements throughout the several views, a flame retardant EMI shielding material according to the present invention is shown generally at **10** in FIG. 1 as generally adapted for use as a jacket within for a foam core gasket construction. For purposes of illustration, material sheet **10** is shown to be of indefinite dimensions which may be cut to size for the particular application envisioned. In basic construction, material **10** includes an upper, generally planar and porous fabric member, **12**, and a lower, flame retardant coating member, **14**.

Fabric member has at least an electrically-conductive first side, **16**, and a conductive or non-conductive second side, **18**, defining a thickness dimension, referenced at "t," in the cross-sectional view of FIG. **2**, which may vary from about 2–4 mils (0.05–0.10 mm). By "electrically-conductive," it is meant that the fabric may be rendered conductive, i.e., to a surface resistivity of about 0.1 Ω/sq. or less, by reason of its being constructed of electrically-conductive wire, monofilaments, yarns or other fibers or, alternatively, by reason of a treatment such as a plating or sputtering being applied to non-conductive fibers to provide an electrically-conductive layer thereon. Preferred electrically-conductive fibers include Monel nickel-copper alloy, silver-plated copper, nickel-clad copper, Ferrex® tin-plated copper-clad steel, aluminum, tin-clad copper, phosphor bronze, carbon, graphite, and conductive polymers. Preferred non-conductive fibers include cotton, wool, silk, cellulose, polyester, polyamide, nylon, and polyimide monofilaments or yarns which are rendered electrically conductive with a metal plating of copper, nickel, silver, nickel-plated-silver, aluminum, tin, or an alloy thereof. As is known, the metal plating may applied to individual fiber strands or to the surfaces of the fabric after weaving, knitting, or other fabrication.

While fabrics such as wire meshes, knits, and non-woven cloths and webs may find application, a preferred fabric construction for member **12** is a plain weave nylon or polyester cloth which is made electrically conductive with between about 20–40% by weight based on the total fabric weight, i.e., 0.01–0.10 g/in^2, of a silver, nickel-silver, or silver-nickel over copper plating. As may be seen in the magnified view of FIG. 1 referenced at **20** in FIG. **3**, such cloth is permeable in having a plain, generally square weave pattern with pores or openings, one of which is referenced at **22**, being defined between the fibers which are represented schematically at **24**. Fibers **24** may be yarns, monofilaments or, preferably, bundles of from about 10–20 filaments or threads, each having a diameter of between about 10–50 μm. For example, with fibers **24** each being a bundle of such threads with a thread count of between about 1000–3000 per inch and a weave count of between about 1000–1500 per inch, 1000–2000 openings per inch will be defined with a mean average pore size of between about 0.5–2 mils (12.5–50 μm).

Although a plain, square weave pattern such as a taffeta, tabby, or ripstop is considered preferred, other weaves such as satins, twills, and the like also should be considered within the scope of the invention herein involved. A particularly preferred cloth for fabric member **12** is a 4 mil (0.10 mm) thick, 1.8 oz/yd^2 weight, silver-plated, woven nylon which is marketed commercially under the designation "31EN RIPSTOP" by Swift Textile Metalizing Corp., Bloomfield, Conn. However, depending upon the needs of the specific shielding application, a fabric constructed of a combination or blend of conductive and nonconductive fibers alternatively may be employed. Examples of fabrics woven, braided, or warp knitted from electrically-conductive fibers, or from blends of conductive and non-conductive fibers, are described in Gladfelter, U.S. Pat. No. 4,684,762, and in Buonanno, U.S. Pat. No. 4,857,668.

Returning to FIGS. **1** and **2**, coating member **14** preferably is formed from a curable layer of a fluent, flame retardant resin or other composition which is wet coated onto the second side **18** of fabric member **12**. As is detailed hereinafter, the viscosity and hydrodynamic pressure of the resin composition are controlled in accordance with the precepts of the present invention to delimit the penetration of the resin layer to a depth, referenced at "d" in FIG. **2**, which is less than the thickness dimension t_1 of the fabric member **12**. In this regard, when the layer is cured to form the flame retardant surface coating member **14** on the second side **18** of fabric member **12**, the first side **16** thereof remains electrically-conductive. In a preferred construction, the layer is coated to a wet thickness of about 10 mils (0.25 mm), and then cured to a dried coating or film thickness, referenced at t_2 in FIG. **2**, of between about 2–4 mils (0.05–0.10 mm) at a depth d of about 1–2 mils (0.025–0.05 mm). Ultimately, a total material thickness, referenced at "T," of between about 6–7 mils (0.15–0.20 mm) and a dried weight pickup of between about 100–150 g/yd^2 are observed. By "cured" it is meant that the resin is polymerized, cross-linked, further cross-linked or polymerized, vulcanized, hardened, dried, volatilized, or otherwise chemically or physically changed from a liquid or other fluent form into a solid polymeric or elastomeric phase.

The flame retardant composition preferably is formulated as an aqueous emulsion of an acrylic latex emulsion which is adjusted to a total solids of about 60% and a Brookfield viscosity (#5 spindle, 4 speed) of between about 40,000–60,000 cps, at a density of about 10 lbs per gallon (1.8 g/cm^3). Flame retardancy may be imparted by loading the emulsion

with between about 30–50% by weight of one or more conventional flame retardant additives such as aluminum hydrate, antimony trioxide, phosphate esters, or halogenated compounds such as polybrominated diphenyl oxides. A preferred formulation is a mixture of about 25% by weight, based on the total weight of the emulsion, of decambromodiphenyl oxide and about 15% by weight of one or more antimony compounds. In operation, should the acrylic carrier phase be ignited, the decomposition of the halogenated and metal oxide compounds function to chemically deprive the flame of sufficient oxygen to support combustion. The decomposition of the acrylic phase additionally may lead to the development of a protective, i.e., thermally-insulative or refractory, outer char layer.

A preferred flame retardant, acrylic latex emulsion is marketed commercially by Heveatex Corp., Fall River, Mass., under the designation "4129FR." The viscosity of the emulsion may be adjusted to between about 40,000–60,000 cps using an aqueous acryloid gel or other acrylic thickener. In this regard, the increased viscosity of the emulsion contributes to delimiting the penetration of the coating layer into the fabric member. However, as this relatively high viscosity may lead to undesirable porosity in the dried film, the emulsion additionally may be modified to reduce air entrapment and bubble formation in the coating layer with up to about 1% by weight of one or more commercial surfactants such as "Bubble Breaker" by Witco Chemical Corp. (Chicago, Ill.) and "Foam Master Antifoam" by Diamond Shamrock, Inc. (San Antonio, Tex.).

As aforementioned, EMI shielding material **10** of the present invention is particularly adapted for use as a flame retardant, electrically-conductive jacket which is provided over a foam core in an EMI shielding gasket construction such as gasket **50** of FIG. **4**. In a representative embodiment, gasket **50** includes an elongate, resilient foam core member, **52**, which may be of an indefinite length. Core member **52** has an outer circumferential surface, **54**, defining the cross-sectional profile of gasket **50** which, for illustrative purposes, is of a generally polygonal, i.e., square or rectangular geometry. Other plane profiles, such as circular, semi-circular, or elliptical, or complex profiles may be substituted, however, depending upon the geometry of the interface to be sealed. Core member **12** may be of any radial or diametric extent, but for most applications will have a diametric extent or width of from about 0.25 inch (0.64 cm) to 1 inch (2.54 cm).

For affording gap-filling capabilities, it is preferred that core member **52** is provided to be complaint over a wide range of temperatures, and to exhibit good compression-relaxation hysteresis even after repeated cyclings or long compressive dwells. Core member **52** therefore may be formed of a foamed elastomeric thermoplastic such as a polyethylene, polypropylene, polypropylene-EPDM blend, butadiene, styrene-butadiene, nitrile, chlorosulfonate, or a foamed neoprene, urethane, or silicone. Preferred materials of construction include open or closed cell urethanes or blends such as a polyolefin resin/monoolefin copolymer blend, or a neoprene, silicone, or nitrile sponge rubber.

Core member **52** may be provided as an extruded or molded foam profile over which shielding material **10** is wrapped as a sheathed, with the edges of sheathed being overlapped as at **56**. In a preferred construction, shielding material **10** is bonded to the core member **52** in a continuous molding process wherein the foam is blown or expanded within the shielding material. As may be seen best with reference to the magnified view of FIG. **4** referenced at **60** in FIG. **5**, in such construction coating member **14** is disposed adjacent core member **52** as an interior surface, **62**, of shielding member **10**, with the uncoated side **16** of fabric member **12** being oppositely disposed as an electrically-conductive exterior surface, **64**, of the gasket **50**. It will be appreciated that the coated interior surface **62** blocks the pores **22** (FIG. **3**) of the fabric member **12** of the fabric to retain the blown foam therein without penetrate or bleed through to the exterior gasket surface **64**. Depending upon the respective compositions of the foam and coating, the interior surface **62** may function, moreover, as a compatibilizing or "tie" interlayer which promotes the bonding of the foam to the fabric. Gasket construction **50** advantageously provides a structure that may be used in very low closure force, i.e. less than about 1 lb/inch (0.175 N/mm), applications.

Referring again to FIG. **4**, an adhesive layer, **70**, may be applied along the lengthwise extent of gasket **50** to the underside of exterior surface **64** for the attachment of the gasket to a substrate. Such layer **70** preferably is formulated to be of a pressure sensitive adhesive (PSA) variety. As is described in U.S. Pat. No. 4,988,550, suitable PSA's for EMI shielding applications include formulations based on silicones, neoprene, styrene butadiene copolymers, acrylics, acrylates, polyvinyl ethers, polyvinyl acetate copolymers, polyisobutylenes, and mixtures, blends, and copolymers thereof. Acrylic-based formulations, however, generally are considered to be preferred for the EMI applications of the type herein involved. Although PSA's are preferred for adhesive layer **70**, other adhesives such as epoxies and urethanes may be substituted and, accordingly, are to be considered within the scope of the present invention. Heat-fusible adhesives such a hot-melts and thermoplastic films additionally may find applicability.

Inasmuch as the bulk conductivity of gasket **50** is determined substantially through its surface contact with the substrate, an electrically-conductive PSA may be preferred to ensure optimal EMI shielding performance. Such adhesives conventionally are formulated as containing about 1–25% by weight of a conductive filler to yield a volume resistivity of from about 0.01–0.001 Ω-cm. The filler may be incorporated in the form of particles, fibers, flakes, microspheres, or microballoons, and may range in size of from about 1–100 microns. Typically filler materials include inherently conductive material such as metals, carbon, and graphite, or nonconductive materials such as plastic or glass having a plating of a conductive material such as a noble metal or the like. In this regard, the means by which the adhesive is rendered electrically conductive is not considered to be a critical aspect of the present invention, such that any means achieving the desired conductivity and adhesion are to be considered suitable.

For protecting the outer portion of adhesive layer **70** which is exposed on the exterior surface of the gasket, a release sheets, shown at **72**, may be provided as removably attached to the exposed adhesive. As is common in the adhesive art, release sheet **72** may be provided as strip of a waxed, siliconized, or other coated paper or plastic sheet or the like having a relatively low surface energy so as to be removable without appreciable lifting of the adhesive from the exterior surface **64**.

In the production of commercial quantities of the EMI shielding material **10** of the present invention, the viscosity adjusted and otherwise modified acrylic latex emulsion or other resin composition may be coated and cured on one side the fabric member **12** by a direct wet process such as knife over roll or slot die. With whatever process is employed, the hydrodynamic pressure of the resin composition is con-

trolled in accordance with the precepts of the present invention to delimit the penetration of the resin layer to a depth which is less than the thickness dimension of the fabric member. For example, and with reference to FIG. **6** wherein the head of a representative gravity-fed knife over roll coater is shown somewhat schematically at **100**, porous, i.e., permeable, fabric member **12** is conveyed from a feed roll or the like (not shown) over a nip roller, **102**, which rotates in the direction referenced by arrow **104**. With the first side **16** of fabric member **12** supported on roller **102**, the fabric second side **18** is passed beneath the opening, referenced at **106**, of a coating trough, **108**. Trough **108** is defined by a front plate, **110**, a back plate, **112**, and a pair of side plates (not shown).

The emulsion or other fluent resin composition, referenced at **114**, is pumped or otherwise transported into trough **108** which is filled to a fluid level, referenced at h. For a given fluid density, this level h is controlled such that the hydrodynamic pressure at the fabric-liquid interface is maintained within preset limits. For example, with a fluid density of about 10 pounds per gallon (1.8 g/cm^3), and a fabric having a porosity of about 1000–2000 openings per inch with a mean average pore size of between about 0.5–2 mils (12.5–50 μm), the fluid level H is controlled at about 4 inches (10 cm) to yield a hydrodynamic pressure of about 0.05 psi (0.35 kPa) at the fabric-liquid interface. For other coating processes, the hydrodynamic fluid pressure may be controlled, for example, by a pumping pressure or the like.

In the illustrative knife-over-roll coating process, the lower edge, **120**, of front plate **110** defines a knife surface which is shimmed or otherwise spaced-apart a predetermined distance from the second side **18** of fabric member **12**. Such spacing provides a clearance or gap, referenced at "g," of typically about 10 mils (0.25 mm), but which is adjustable to regulate the thickness of the liquid coating layer, **122**, being applied to the fabric member. From roller **104**, the coated fabric member **12** may be conveyed via a take-up roller arrangement (not shown) through a in-line oven or the like to dry or flash the water or other diluent in the liquid coating layer **122**, or to otherwise cure the liquid coating layer **122** in developing an adherent, tack-free, film or other layer of coating member **14** (FIG. **1**) on the single side **18** of fabric member **12**.

The Example to follow, wherein all percentages and proportions are by weight unless otherwise expressly indicated, is illustrative of the practicing of the invention herein involved, but should not be construed in any limiting sense.

EXAMPLE

Representative EMI shielding materials according to the present invention were constructed for characterization. In this regard, a master batch of a flame retardant coating composition was compounded using an acrylic latex emulsion (Heveatex "4129FR"). The viscosity of the emulsion was adjusted to a Brookfield viscosity (#4 spindle, 40 speed) of about 60,000 cps with about 5 wt % of an acryloid thickener (Acrysol™ GS, Monsanto Co., St. Louis, Mo.). The modified emulsion had a total solids content of about 60% by weight, a density of about 10 pounds per gallon (1.8 g/cm^3), and a pH of between about 7.5 and 9.5.

The emulsion was applied using a knife over roll coater (JETZONE Model 7319, Wolverine Corp., Merrimac, Mass.) to one side of a silver-plated nylon fabric (Swift "31EN RIPSTOP") having a thickness of about 4 mils (0.1 mm). With the fluid level in the coating trough of the coater maintained at about 4 inch (10 cm), the emulsion was delivered to the surface of the cloth at a hydrodynamic pressure of about 0.05 psi (0.35 kPa). The coating knife was shimmed to a 10 mil (0.25 mm) gap above the fabric to yield a wet coating draw down thickness of about 10 mils. Following an oven curing at 100–125° C. for 5 minutes, a dried coating or film thickness of about 2.5 mils (0.635 mm) was obtained with a weight pickup of about 130–145 g/yd^2 and a total material thickness of between about 6–7 mils (0.15–0.18 mm). An inspection of the coated fabric cloth revealed a coating penetration depth of about 1–2 mils (0.02–0.05 mm) providing acceptable mechanical retention and/or adhesion of the coating onto the fabric surface. The opposite side of the fabric, however, was observed to be substantially coating free, and to retain a surface resistivity of about 0.1 Ω/sq for unaffected EMI shielding effectiveness.

Fabric samples similarly coated in the manner described were subjected to an in-house vertical flame test. No burning was observed at dried film thickness of 2, 3, or 4 mils (0.05, 0.08, 0.10 mm). Accordingly, a reasonable operating window of film thickness was suggested for production runs.

Samples also were provided, as jacketed over a polyurethane foam core in an EMI shielding gasket construction, for flame testing by Underwriters Laboratories, Inc., Melville, N.Y. A flame class rating of V-0 under UL94 was assigned at a minimum thickness of 1.0 mm. The gasket construction therefore was found to be compliant with the applicable UL requirements, and was approved to bear the "UL" certification mark.

The foregoing results confirm that, the EMI shielding material of the present invention affords UL94 V-0 protection when used as a jacketing in a fabric-over-foam gasket construction. Unexpectedly, it was found that a relatively porous or permeable fabric may be wet coated on one side with a relatively thin, i.e., 2–4 mil (0.05–0.10 mm), coating layer of a flame retardant composition without compromising the electrical surface conductivity of the other side. Such a thin coating layer, while being sufficient to provide UL94 V-0 protection in a conventional fabric-over-foam gasket construction, nonetheless maintains the drapability the fabric and thereby facilitates the fabrication of UL94 V-0 compliant gaskets having complex profiles or narrow cross-sections down to about 1 mm.

As it is anticipated that certain changes may be made in the present invention without departing from the precepts herein involved, it is intended that all matter contained in the foregoing description shall be interpreted as illustrative and not in a limiting sense. All references cited herein are expressly incorporated by reference.

What is claimed is:

1. A flame retardant, electromagnetic interference (EMI) shielding gasket comprising:

a resilient core member extending lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis, said core member being formed of a foamed elastomeric material;

an electrically-conductive fabric member surrounding the outer surface of said core member, said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface, at least the exterior surface being electrically-conductive and the exterior surface defining with the interior surface a thickness dimension of the fabric member therebetween; and

a flame retardant layer coating at least a portion of the interior surface of said fabric member, said flame retardant layer comprising at least about 30% by weight of one or more flame retardant additives and penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive.

2. The gasket of claim 1 wherein said flame retardant layer has a thickness of between about 2–4 mils (0.05–0.10 mm).

3. The gasket of claim 1 wherein said flame retardant layer is formed as a cured film of a flame retardant acrylic latex emulsion.

4. The gasket of claim 1 wherein said fabric member is a metal-plated cloth.

5. The gasket of claim 4 wherein said cloth comprises fibers selected from the group consisting of cotton, wool, silk, cellulose, polyester, polyamide, nylon, and combinations thereof, and said metal is selected from the group consisting of copper, nickel, silver, nickel-plated-silver, aluminum, tin, and combinations thereof.

6. The gasket of claim 1 wherein said foamed elastomeric material is selected from the group consisting of polyethylenes, polypropylenes, polypropylene-EPDM blends, butadienes, styrene-butadienes, nitriles, chlorosulfonates, neoprenes, urethanes, silicones, and polyolefin resin/monoolefin copolymer blends, and combinations thereof.

7. The gasket of claim 1 wherein said fabric member has a thickness of between about 2–4 mils (0.05–0.10 mm).

8. The gasket of claim 1 wherein said flame retardant layer is effective to afford the gasket a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94.

9. The gasket of claim 1 wherein said one or more flame retardant additives are selected from the group consisting of aluminum hydrate, antimony trioxide, phosphate esters, and halogenated compounds.

* * * * *

EXHIBIT C

EXHIBIT C

US006777095B2

(12) **United States Patent**
Bunyan et al.

(10) **Patent No.: US 6,777,095 B2**
(45) **Date of Patent: Aug. 17, 2004**

(54) **FLAME RETARDANT EMI SHIELDING GASKET**

(75) Inventors: **Michael H. Bunyan**, Chelmsford, MA (US); **William I. Flanders**, Merimack, NH (US)

(73) Assignee: **Parker-Hannifin Corporation**, Cleveland, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/753,016**

(22) Filed: **Jan. 7, 2004**

(65) **Prior Publication Data**

US 2004/0142616 A1 Jul. 22, 2004

Related U.S. Application Data

(63) Continuation of application No. 10/318,609, filed on Dec. 11, 2002, now Pat. No. 6,716,536, which is a continuation of application No. 10/142,803, filed on May 9, 2002, now Pat. No. 6,521,348, which is a continuation of application No. 09/883,785, filed on Jun. 18, 2001, now Pat. No. 6,387,523, which is a continuation of application No. 09/250,338, filed on Feb. 16, 1999, now Pat. No. 6,248,393.

(60) Provisional application No. 60/076,370, filed on Feb. 27, 1998.

(51) **Int. Cl.**[7] **B32B 5/14**; B32B 5/18; H05K 9/00

(52) **U.S. Cl.** **428/457**; 361/818

(58) **Field of Search** 428/457; 361/818

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,178,410	A	12/1979	Tomita
4,396,661	A	8/1983	George et al.
4,447,484	A	5/1984	Slosberg et al.
4,489,126	A	12/1984	Holtrop et al.
4,531,994	A	7/1985	Holtrop et al.
4,540,617	A	9/1985	Kawanishi et al.
4,569,304	A	2/1986	Le Maitre
4,572,960	A	2/1986	Ebneth et al.
4,608,104	A	8/1986	Holtrop et al.
4,621,013	A	11/1986	Holtrop et al.
4,666,765	A	5/1987	Caldwell et al.
4,684,762	A	8/1987	Gladfelter
4,753,840	A	6/1988	Van Gompel
4,797,171	A	1/1989	Van Gompel
4,857,668	A	8/1989	Buonanno
4,871,477	A	10/1989	Dimanshteyn
4,988,550	A	1/1991	Keyser et al.
5,009,927	A	4/1991	Cloyd et al.
5,028,739	A	7/1991	Keyser et al.
5,045,635	A	9/1991	Kaplo et al.

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

DE	9013936	6/1990
EP	0326441	2/1989
FR	2308030	12/1976
JP	07-176889	* 7/1995

OTHER PUBLICATIONS

Dye, James M. Compliance Engineering 17(3), pp 138 and 140–145, 2000.*

Kleiner, J. Vinyl Technol. vol. 4 No. 4, Dec. 1982, pp 157–159.*

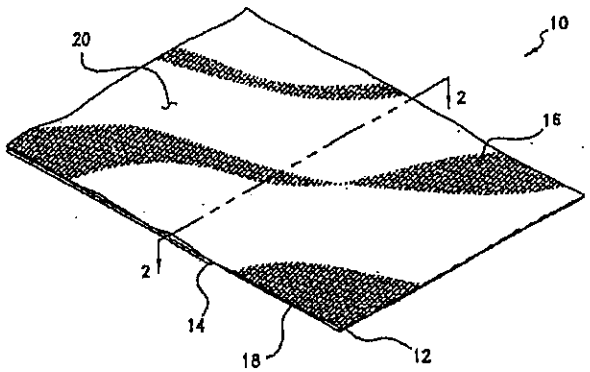
(List continued on next page.)

Primary Examiner—Erma Cameron
(74) *Attorney, Agent, or Firm*—John A. Molnar, Jr.

(57) **ABSTRACT**

A flame retardant, electromagnetic interference (EMI) shielding gasket construction. The construction includes a resilient core member formed of a foamed elastomeric material, an electrically-conductive fabric member surrounding the outer surface of the core member, and a flame retardant layer coating at least a portion of the interior surface of the fabric member. The flame retardant layer is effective to afford the gasket construction with a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94.

10 Claims, 3 Drawing Sheets



U.S. PATENT DOCUMENTS

5,089,325	A	2/1992	Covey
5,105,056	A	4/1992	Hoge, Jr. et al.
5,122,411	A	6/1992	Iwamoto et al.
5,202,536	A	4/1993	Buonanno
5,204,403	A	4/1993	Furuta et al.
5,266,354	A	11/1993	Tohyama et al.
5,612,092	A	3/1997	Strenger et al.
5,614,306	A	3/1997	Jobe et al.
5,635,252	A	6/1997	Fraser, Jr. et al.
5,641,544	A	6/1997	Meluncon et al.
5,674,606	A	10/1997	Powers, Jr.
5,700,532	A	12/1997	Chiou

OTHER PUBLICATIONS

Underwriters Laboratories, Inc. letter dated Sep. 20, 1995.
Copy of the International Application Published Under the Patent Cooperation Treaty in International Patent Application No. PCT/US00/20609 (WO 01/10182) entitled, "Method and Apparatus for Manufacturing A Flame Retardant EMI Gasket".
Copy of International Search Report for PCT Case No. PCT/US99/04100, Jan. 7, 1999.
Chomerics Parker Hannifin Seals Catalog dated 1997 for Soft-Shield Low Closure force EMI Gaskets.
Monsanto Flectron Metalized Materials dated Sep. 12, 1995.

* cited by examiner

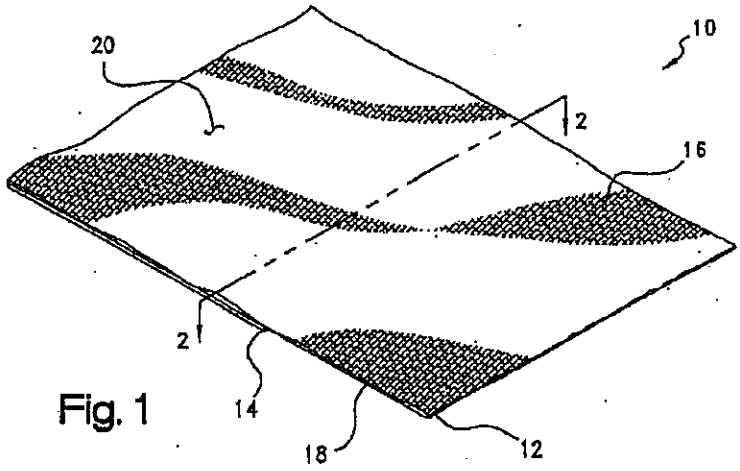


Fig. 1

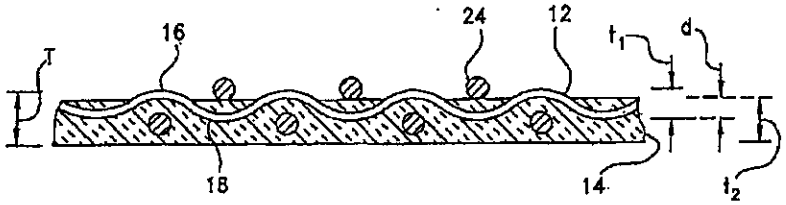


Fig. 2

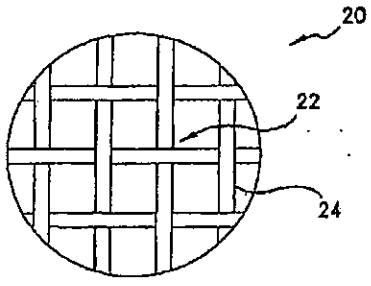


Fig. 3

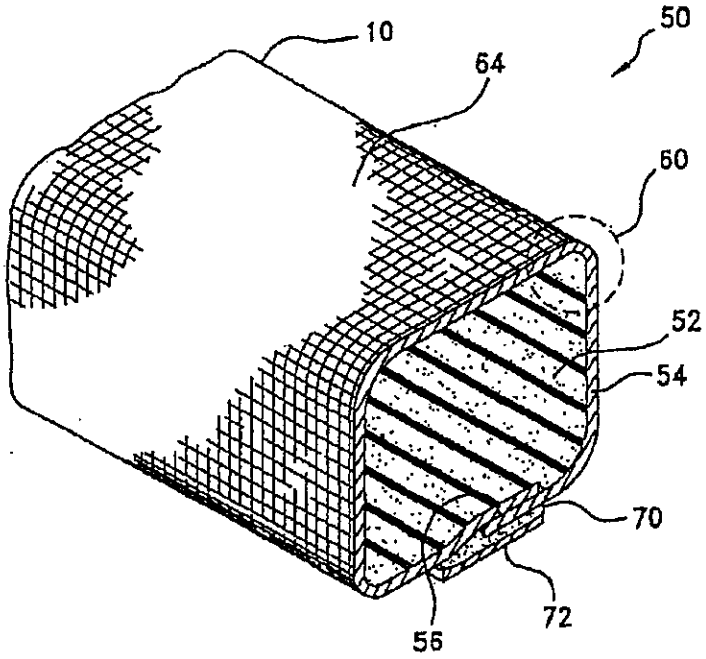


Fig. 4

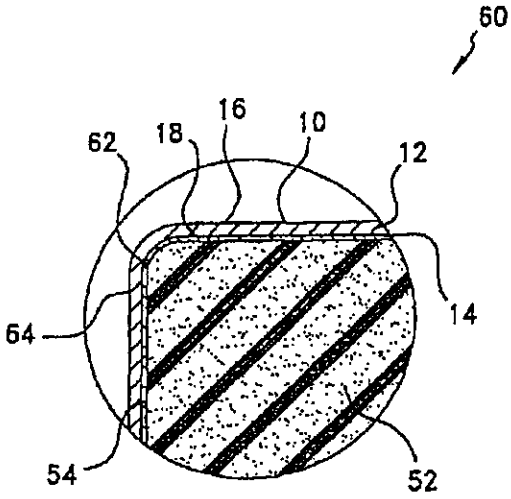


Fig. 5

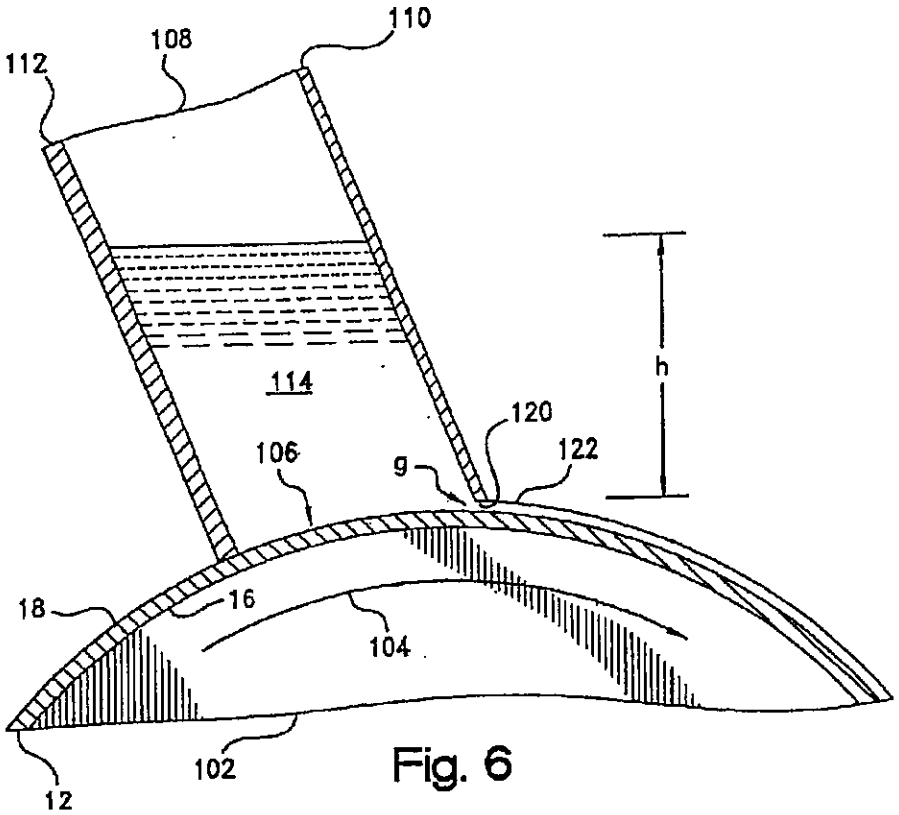


Fig. 6

FLAME RETARDANT EMI SHIELDING GASKET

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. application Ser. No. 10/318,609, filed Dec. 11, 2002, now U.S. Pat. No. 6,716,536; which is a continuation of U.S. application Ser. No. 10/142,803, filed May 9, 2002, now U.S. Pat. No. 6,521,348; which is a continuation of U.S. application Ser. No. 09/883,785, filed Jun. 18, 2001, now U.S. Pat. No. 6,387,523; which is a continuation of U.S. application Ser. No. 09/250,338, filed Feb. 16, 1999, now U.S. Pat. No. 6,248,393 and claiming priority to U.S. Provisional application Serial No. 60/076,370, filed Feb. 27, 1998, the disclosure of each of which is expressly incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates broadly to electrically-conductive, flame retardant materials for use in electromagnetic interference (EMI) shielding, and to a method of manufacturing the same, and more particularly to an electrically-conductive fabric having a layer of a flame retardant coating applied to one surface thereof for use as a sheathing within an EMI shielding gasket.

The operation of electronic devices including televisions, radios, computers, medical instruments, business machines, communications equipment, and the like is attended by the generation of electromagnetic radiation within the electronic circuitry of the equipment. Such radiation often develops as a field or as transients within the radio frequency band of the electromagnetic spectrum, i.e., between about 10 KHz and 10 GHz, and is termed "electromagnetic interference" or "EMI" as being known to interfere with the operation of other proximate electronic devices.

To attenuate EMI effects, shielding having the capability of absorbing and/or reflecting EMI energy may be employed both to confine the EMI energy within a source device, and to insulate that device or other "target" devices from other source devices. Such shielding is provided as a barrier which is inserted between the source and the other devices, and typically is configured as an electrically conductive and grounded housing which encloses the device. As the circuitry of the device generally must remain accessible for servicing or the like, most housings are provided with openable or removable accesses such as doors, hatches, panels, or covers. Between even the flattest of these accesses and its corresponding mating or faying surface, however, there may be present gaps which reduce the efficiency of the shielding by presenting openings through which radiant energy may leak or otherwise pass into or out of the device. Moreover, such gaps represent discontinuities in the surface and ground conductivity of the housing or other shielding, and may even generate a secondary source of EMI radiation by functioning as a form of slot antenna. In this regard, bulk or surface currents induced within the housing develop voltage gradients across any interface gaps in the shielding, which gaps thereby function as antennas which radiate EMI noise. In general, the amplitude of the noise is proportional to the gap length, with the width of the gap having a less appreciable effect.

For filling gaps within mating surfaces of housings and other EMI shielding structures, gaskets and other seals have been proposed both for maintaining electrical continuity across the structure, and for excluding from the interior of the device such contaminates as moisture and dust. Such seals are bonded or mechanically attached to, or press-fit into, one of the mating surfaces, and function to close any interface gaps to establish a continuous conductive path thereacross by conforming under an applied pressure to irregularities between the surfaces. Accordingly, seals intended for EMI shielding applications are specified to be of a construction which not only provides electrical surface conductivity even while under compression, but which also has a resiliency allowing the seals to conform to the size of the gap. The seals additionally must be wear resistant, economical to manufacture, and capability of withstanding repeated compression and relaxation cycles. For further information on specifications for EMI shielding gaskets, reference may be had to Severinsen, J., "Gaskets That Block EMI," Machine Design, Vol. 47, No. 19, pp. 74–77 (Aug. 7, 1975).

Requirements for typical EMI shielding applications often dictate a low impedance, low profile gasket which is deflectable under normal closure force loads. Other requirements include low cost and a design which provides an EMI shielding effectiveness for both the proper operation of the device and compliance, in the United States, with commercial Federal Communication Commission (FCC) EMC regulations.

A particularly economical gasket construction, which also requires very low closure forces, i.e. less than about 1 lb/inch (0.175 N/mm), is marketed by the Chomerics Division of Parker-Hannifin Corp., Woburn, Mass. under the tradenarne "Soft-Shield ® 5000 Series." Such construction consists of an electrically-conductive jacket or sheathing which is "cigarette" wrapped lengthwise over a polyurethane or other foam core. As is described further in U.S. Pat. No. 4,871,477, polyurethane foams generally are produced by the reaction of polyisocyanate and a hydroxyl-functional polyol in the presence of a blowing agent. The blowing agent effects the expansion of the polymer structure into a multiplicity of open or closed cells.

The jacket is provided as a highly conductive, i.e., about 1 Ω-sq., nickel-plated-silver, woven rip-stop nylon which is self-terminating when cut. Advantageously, the jacket may be bonded to the core in a continuous molding process wherein the foam is blown or expanded within the jacket as the jacket is wrapped around the expanding foam and the foam and jacket are passed through a die and into a traveling molding. Similar gasket constructions are shown in commonly-assigned U.S. Pat. No. 5,028,739 and in U.S. Pat. Nos. 4,857,668; 5,054,635; 5,105,056; and 5,202,536.

Many electronic devices, including PC's and communication equipment, must not only comply with certain FCC requirements, but also must meet be approved under certain Underwriter's Laboratories (UL) standards for flame retardancy. In this regard, if each of the individual components within an electronic device is UL approved, then the device itself does not require separate approval. Ensuring UL approval for each component therefore reduces the cost of compliance for the manufacturer, and ultimately may result in cheaper goods for the consumer. For EMI shielding gaskets, however, such gaskets must be made flame retardant, i.e., achieving a rating of V-0 under UL Std. No. 94, "Tests for Flammability of Plastic Materials for Parts in Devices and Appliances" (1991), without compromising the electrical conductivity necessary for meeting EMI shielding requirements.

In this regard, and particularly with respect to EMI shielding gaskets of the above-described fabric over foam

variety, it has long been recognized that foamed polymeric materials are flammable and, in certain circumstances, may present a fire hazard. Owing to their cellular structure, high organic content, and surface area, most foam materials are subject to relatively rapid decomposition upon exposure to fire or high temperatures.

One approach for imparting flame retardancy to fabric over foam gaskets has been to employ the sheathing as a flame resistant protective layer for the foam. Indeed, V-0 rating compliance purportedly has been achieved by sheathing the foam within an electrically-conductive Ni/Cu-plated fabric to which a thermoplastic sheet is hot nipped or otherwise fusion bonding to the underside thereof. Such fabrics, which may be further described in one or more of U.S. Pat. Nos. 4,489,126; 4,531,994; 4,608,104; and/or 4,621,013, have been marketed by Monsanto Co., St. Louis, under the tradename "Flectron® Ni/Cu Polyester Taffeta V0."

Other fabric over foam gaskets, as is detailed in U.S. Pat. No. 4,857,668, incorporate a supplemental layer or coating applied to the interior surface of the sheath. Such coating may be a flame-retardant urethane formulation which also promotes the adhesion of the sheath to the foam. The coating additionally may function to reduce bleeding of the foam through the fabric which otherwise could compromise the electrical conductivity of the sheath.

In view of the foregoing, it will be appreciated that further improvements in the design of flame retardant, fabric-over foam EMI shielding gaskets, as well as sheathing materials therefore, would be well-received by the electronics industry. Especially desired would be a flame retardant gasket construction which achieves a UL94 rating of V-0.

BROAD STATEMENT OF THE INVENTION

The present invention is directed to an electrically-conductive, flame retardant material for use in fabric-over-foam EMI shielding gaskets, and to a method of manufacturing the same. In having a layer of a flame retardant coating applied to one side of an electrically-conductive, generally porous fabric, the material of the invention affords UL94 V-0 protection when used as a jacketing in a fabric-over-foam gasket construction. Advantageously, as the flame retardant layer may be wet coated on the fabric without appreciable bleed through, a relatively thin, i.e., 2–4 mil (0.05–0.10 mm), coating layer may be provided on one fabric side without compromising the electrical surface conductivity of the other side. Such a thin coating layer, while being sufficient to provide UL94 V-0 protection, nonetheless maintains the drapability the fabric and thereby facilitates the construction UL94 V-0 compliant gaskets having complex profiles or narrow cross-sections down to about 1 mm.

In a preferred embodiment, the electrically-conductive, flame retardant EMI shielding material of the invention includes a nickel or silver-plated, woven nylon, polyester, or like fabric on one side of which is wet coated a layer of a flame retardant, acrylic latex emulsion or other fluent resin composition. In accordance with the precepts of the method of the invention, the viscosity and hydrodynamic pressure of the emulsion are controlled such that the coating does not penetrate or otherwise "bleed through" the uncoated side of the fabric. The surface conductivity of the opposite side of the fabric therefore is not compromised in EMI shielding applications.

The material of the invention may be employed as a jacket in fabric-over-foam EMI shielding gasket constructions, and is particularly adapted for use in the continuous molding process for such gaskets. As used within such process, the fabric may be wrapped around the foam as a jacket with coated side thereof being disposed as an interior surface adjacent the foam, and the uncoated side being disposed as an electrically-conductive exterior surface. Advantageously, the coating on the interior surface of the jacket blocks the pores of the fabric to retain the foam therein without penetrate or bleed through to the exterior surface. In being formed of a acrylic material, the coated interior surface of the jacket may function, moreover, depending upon the composition of the foam, as a compatibilizing or "tie" interlayer which promotes the bonding of the foam to the fabric.

The present invention, accordingly, comprises material and method possessing the construction, combination of elements, and arrangement of parts and steps which are exemplified in the detailed disclosure to follow. Advantages of the present invention include a flame retardant yet drapable EMI shielding fabric. Additional advantages include an economical, flame retardant EMI shielding fabric construction wherein a relatively thin layer of a flame retardant coating may be wet coated onto one side of an electrically-conductive, woven or other generally porous EMI shielding fabric without compromising the conductivity of the other side of the fabric. These and other advantages will be readily apparent to those skilled in the art based upon the disclosure contained herein.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIG. 1 is a perspective view of one embodiment of an EMI shielding material according to the present invention which material includes a generally planar fabric member on one side of which is coated a layer of a flame retardant composition, the view being shown with portions being broken away to better reveal the structure of the material;

FIG. 2 is an enlarged cross-sectional view of the EMI shielding material of FIG. 1 taken through plane represented by line 2—2 of FIG. 1;

FIG. 3 is a top view of the material of FIG. 1 which is magnified to reveal the structure of the fabric member thereof;

FIG. 4 is a perspective cross-sectional view of a length of a representative EMI shielding gasket construction according to the present invention including a jacket which is formed of the EMI shielding material of FIG. 1;

FIG. 5 is an end view of the gasket of FIG. 4 which is magnified to reveal the structure thereof; and

FIG. 6 is a schematic, partially cross-sectional view of an illustrative gravity-fed, knife over roll coater as adapted for use in the manufacture of the EMI shielding material of FIG. 1.

The drawings will be described further in connection with the following Detailed Description of the Invention.

DETAILED DESCRIPTION OF THE INVENTION

Certain terminology may be employed in the description to follow for convenience rather than for any limiting purpose. For example, the terms "upper" and "lower" designate directions in the drawings to which reference is made,

with the terms "inner" or "interior" and "outer" or "exterior" referring, respectively, to directions toward and away from the center of the referenced element, and the terms "radial" and "axial" referring, respectively, to directions perpendicular and parallel to the longitudinal central axis of the referenced element. Terminology of similar import other than the words specifically mentioned above likewise is to be considered as being used for purposes of convenience rather than in any limiting sense.

For the illustrative purposes of the discourse to follow, the electromagnetic interference (EMI) shielding material herein involved is described in connection with its use as a flame retardant, electrically-conductive jacket for a foam core, EMI shielding gasket as may be adapted to be received within an interface, such as between a door, panel, hatch, cover, or other parting line of an electromagnetic interference (EM) shielding structure. The EMI shielding structure may be the conductive housing of a computer, communications equipment, or other electronic device or equipment which generates EMI radiation or is susceptible to the effects thereof. The gasket may be bonded or fastened to, or press-fit into one of a pair of mating surfaces which define the interface within the housing, and functions between the mating surfaces to seal any interface gaps or other irregularities. That is, while under an applied pressure, the gasket resiliently conforms to any such irregularities both to establish a continuous conductive path across the interface, and to environmentally seal the interior of the housing against the ingress of dust, moisture, or other contaminates. It will be appreciated, however, that aspects of the present invention may find utility in other EMI shielding applications. Use within those such other applications therefore should be considered to be expressly within the scope of the present invention.

Referring then to the figures, wherein corresponding reference characters are used to designate corresponding elements throughout the several views, a flame retardant EMI shielding material according to the present invention is shown generally at **10** in FIG. **1** as generally adapted for use as a jacket within for a foam core gasket construction. For purposes of illustration, material sheet **10** is shown to be of indefinite dimensions which may be cut to size for the particular application envisioned. In basic construction, material **10** includes an upper, generally planar and porous fabric member, **12**, and a lower, flame retardant coating member, **14**.

Fabric member has at least an electrically-conductive first side, **16**, and a conductive or non-conductive second side, **18**, defining a thickness dimension, referenced at "t_1" in the cross-sectional view of FIG. **2**, which may vary from about 2–4 mils (0.05–0.10 mm). By "electrically-conductive," it is meant that the fabric may be rendered conductive, i.e., to a surface resistivity of about 0.1 Ω/sq. or less, by reason of its being constructed of electrically-conductive wire, monofilaments, yams or other fibers or, alternatively, by reason of a treatment such as a plating or sputtering being applied to non-conductive fibers to provide an electrically-conductive layer thereon. Preferred electrically-conductive fibers include Monel nickel-copper alloy, silver-plated copper, nickel-clad copper, Ferrex® tin-plated copper-clad steel, aluminum, tin-clad copper, phosphor bronze, carbon, graphite, and conductive polymers. Preferred non-conductive fibers include cotton, wool, silk, cellulose, polyester, polyanide, nylon, and polyimide monofilaments or yarns which are rendered electrically conductive with a metal plating of copper, nickel, silver, nickel-plated-silver, aluminum, tin, or an alloy thereof. As is known, the metal plating may applied to individual fiber strands or to the surfaces of the fabric after weaving, knitting, or other fabrication.

While fabrics such as wire meshes, knits, and non-woven cloths and webs may find application, a preferred fabric construction for member **12** is a plain weave nylon or polyester cloth which is made electrically conductive with between about 20–40% by weight based on the total fabric weight, i.e., 0.01–0.10 g/in^2, of a silver, nickel-silver, or silver-nickel over copper plating. As may be seen in the magnified view of FIG. **1** referenced at **20** in FIG. **3**, such cloth is permeable in having a plain, generally square weave pattern with pores or openings, one of which is referenced at **22**, being defined between the fibers which are represented schematically at **24**. Fibers **24** may be yarns, monofilaments or, preferably, bundles of from about 10–20 filaments or threads, each having a diameter of between about 10–50 μm. For example, with fibers **24** each being a bundle of such threads with a thread count of between about 1000–3000 per inch and a weave count of between about 1000–1500 per inch, 1000–2000 openings per inch will be defined with a mean average pore size of between about 0.5–2 mils (12.5–50 μm).

Although a plain, square weave pattern such as a taffeta, tabby, or ripstop is considered preferred, other weaves such as satins, twills, and the like also should be considered within the scope of the invention herein involved. A particularly preferred cloth for fabric member **12** is a 4 mil (0.10 mm) thick, 1.8 oz/yd^2 weight, silver-plated, woven nylon which is marketed commercially under the designation "31EN RIPSTOP" by Swift Textile Metalizing Corp., Bloomfield, Conn. However, depending upon the needs of the specific shielding application, a fabric constructed of a combination or blend of conductive and nonconductive fibers alternatively may be employed. Examples of fabrics woven, braided, or warp knitted from electrically-conductive fibers, or from blends of conductive and non-conductive fibers, are described in Gladfelter, U.S. Pat. No. 4,684,762, and in Buonanno, U.S. Pat. No. 4,857,668.

Returning to FIGS. **1** and **2**, coating member **14** preferably is formed from a curable layer of a fluent, flame retardant resin or other composition which is wet coated onto the second side **18** of fabric member **12**. As is detailed hereinafter, the viscosity and hydrodynamic pressure of the resin composition are controlled in accordance with the precepts of the present invention to delimit the penetration of the resin layer to a depth, referenced at "d" in FIG. **2**, which is less than the thickness dimension t_1 of the fabric member **12**. In this regard, when the layer is cured to form the flame retardant surface coating member **14** on the second side **18** of fabric member **12**, the first side **16** thereof remains electrically-conductive. In a preferred construction, the layer is coated to a wet thickness of about 10 mils (0.25 mm), and then cured to a dried coating or film thickness, referenced at t_2 in FIG. **2**, of between about 2–4 mils (0.05–0.10 mm) at a depth *d* of about 1–2 mils (0.025–0.05 mm). Ultimately, a total material thickness, referenced at "T," of between about 6–7 mils (0.15–0.20 mm) and a dried weight pickup of between about 100–150 g/yd^2 are observed. By "cured" it is meant that the resin is polymerized, cross-linked, further cross-linked or polymerized, vulcanized, hardened, dried, volatilized, or otherwise chemically or physically changed from a liquid or other fluent form into a solid polymeric or elastomeric phase.

The flame retardant composition preferably is formulated as an aqueous emulsion of an acrylic latex emulsion which is adjusted to a total solids of about 60% and a Brookfield

viscosity (#5 spindle, 4 speed) of between about 40,000–60,000 cps, at a density of about 10 lbs per gallon (1.8 g/cm^3). Flame retardancy may be imparted by loading the emulsion with between about 30–50% by weight of one or more conventional flame retardant additives such as aluminum hydrate, antimony trioxide, phosphate esters, or halogenated compounds such as polybrominated diphenyl oxides. A preferred formulation is a mixture of about 25% by weight, based on the total weight of the emulsion, of decambromodiphenyl oxide and about 15% by weight of one or more antimony compounds. In operation, should the acrylic carrier phase be ignited, the decomposition of the halogenated and metal oxide compounds function to chemically deprive the flame of sufficient oxygen to support combustion. The decomposition of the acrylic phase additionally may lead to the development of a protective, i.e., thermally-insulative or refractory, outer char layer.

A preferred flame retardant, acrylic latex emulsion is marketed commercially by Heveatex Corp., Fall River, Mass., under the designation "4129FR." The viscosity of the emulsion may be adjusted to between about 40,000–60,000 cps using an aqueous acryloid gel or other acrylic thickener. In this regard, the increased viscosity of the emulsion contributes to delimiting the penetration of the coating layer into the fabric member. However, as this relatively high viscosity may lead to undesirable porosity in the dried film, the emulsion additionally may be modified to reduce air entrapment and bubble formation in the coating layer with up to about 1% by weight of one or more commercial surfactants such as "Bubble Breaker" by Witco Chemical Corp. (Chicago, Ill.) and "Foam Master Antifoam" by Diamond Shamrock, Inc. (San Antonio, Tex.).

As aforementioned, EMI shielding material **10** of the present invention is particularly adapted for use as a flame retardant, electrically-conductive jacket which is provided over a foam core in an EMI shielding gasket construction such as gasket **50** of FIG. **4**. In a representative embodiment, gasket **50** includes an elongate, resilient foam core member, **52**, which may be of an indefinite length. Core member **52** has an outer circumferential surface, **54**, defining the cross-sectional profile of gasket **50** which, for illustrative purposes, is of a generally polygonal, i.e., square or rectangular geometry. Other plane profiles, such as circular, semi-circular, or elliptical, or complex profiles may be substituted, however, depending upon the geometry of the interface to be sealed. Core member **12** may be of any radial or diametric extent, but for most applications will have a diametric extent or width of from about 0.25 inch (0.64 cm) to 1 inch (2.54 cm).

For affording gap-filling capabilities, it is preferred that core member **52** is provided to be complaint over a wide range of temperatures, and to exhibit good compression-relaxation hysteresis even after repeated cyclings or long compressive dwells. Core member **52** therefore may be formed of a foamed elastomeric thermoplastic such as a polyethylene, polypropylene, polypropylene-EPDM blend, butadiene, styrene-butadiene, nitrile, chlorosulfonate, or a foamed neoprene, urethane, or silicone. Preferred materials of construction include open or closed cell urethanes or blends such as a polyolefin resin/monoolefin copolymer blend, or a neoprene, silicone, or nitrile sponge rubber.

Core member **52** may be provided as an extruded or molded foam profile over which shielding material **10** is wrapped as a sheathed, with the edges of sheathed being overlapped as at **56**. In a preferred construction, shielding material **10** is bonded to the core member **52** in a continuous molding process wherein the foam is blown or expanded within the shielding material. As may be seen best with reference to the magnified view of FIG. **4** referenced at **60** in FIG. **5**, in such construction coating member **14** is disposed adjacent core member **52** as an interior surface, **62**, of shielding member **10**, with the uncoated side **16** of fabric member **12** being oppositely disposed as an electrically-conductive exterior surface, **64**, of the gasket **50**. It will be appreciated that the coated interior surface **62** blocks the pores **22** (FIG. **3**) of the fabric member **12** of the fabric to retain the blown foam therein without penetrate or bleed through to the exterior gasket surface **64**. Depending upon the respective compositions of the foam and coating, the interior surface **62** may function, moreover, as a compatibilizing or "tie" interlayer which promotes the bonding of the foam to the fabric. Gasket construction **50** advantageously provides a structure that may be used in very low closure force, i.e. less than about 1 lb/inch (0.175 N/mm), applications.

Referring again to FIG. **4**, an adhesive layer, **70**, may be applied along the lengthwise extent of gasket **50** to the underside of exterior surface **64** for the attachment of the gasket to a substrate. Such layer **70** preferably is formulated to be of a pressure sensitive adhesive (PSA) variety. As is described in U.S. Pat. No. 4,988,550, suitable PSA's for EMI shielding applications include formulations based on silicones, neoprene, styrene butadiene copolymers, acrylics, acrylates, polyvinyl ethers, polyvinyl acetate copolymers, polyisobutylenes, and mixtures, blends, and copolymers thereof. Acrylic-based formulations, however, generally are considered to be preferred for the EMI applications of the type herein involved. Although PSA's are preferred for adhesive layer **70**, other adhesives such as epoxies and urethanes may be substituted and, accordingly, are to be considered within the scope of the present invention. Heat-fusible adhesives such a hot-melts and thermoplastic films additionally may find applicability.

Inasmuch as the bulk conductivity of gasket **50** is determined substantially through its surface contact with the substrate, an electrically-conductive PSA may be preferred to ensure optimal EMI shielding performance. Such adhesives conventionally are formulated as containing about 1–25% by weight of a conductive filler to yield a volume resistivity of from about 0.01–0.001 Ω-cm. The filler may be incorporated in the form of particles, fibers, flakes, microspheres, or microballoons, and may range in size of from about 1–100 microns. Typically filler materials include inherently conductive material such as metals, carbon, and graphite, or nonconductive materials such as plastic or glass having a plating of a conductive material such as a noble metal or the like. In this regard, the means by which the adhesive is rendered electrically conductive is not considered to be a critical aspect of the present invention, such that any means achieving the desired conductivity and adhesion are to be considered suitable.

For protecting the outer portion of adhesive layer **70** which is exposed on the exterior surface of the gasket, a release sheets, shown at **72**, may be provided as removably attached to the exposed adhesive. As is common in the adhesive art, release sheet **72** may be provided as strip of a waxed, siliconized, or other coated paper or plastic sheet or the like having a relatively low surface energy so as to be removable without appreciable lifting of the adhesive from the exterior surface **64**.

In the production of commercial quantities of the EMI shielding material **10** of the present invention, the viscosity adjusted and otherwise modified acrylic latex emulsion or other resin composition may be coated and cured on one side

the fabric member **12** by a direct wet process such as knife over roll or slot die. With whatever process is employed, the hydrodynamic pressure of the resin composition is controlled in accordance with the precepts of the present invention to delimit the penetration of the resin layer to a depth which is less than the thickness dimension of the fabric member. For example, and with reference to FIG. **6** wherein the head of a representative gravity-fed knife over roll coater is shown somewhat schematically at **100**, porous, i.e., permeable, fabric member **12** is conveyed from a feed roll or the like (not shown) over a nip roller, **102**, which rotates in the direction referenced by arrow **104**. With the first side **16** of fabric member **12** supported on roller **102**, the fabric second side **18** is passed beneath the opening, referenced at **106**, of a coating trough, **108**. Trough **108** is defined by a front plate, **10**, a back plate, **112**, and a pair of side plates (not shown).

The emulsion or other fluent resin composition, referenced at **114**, is pumped or otherwise transported into trough **108** which is filled to a fluid level, referenced at h. For a given fluid density, this level h is controlled such that the hydrodynamic pressure at the fabric-liquid interface is maintained within preset limits. For example, with a fluid density of about 10 pounds per gallon (1.8 g/cm^3), and a fabric having a porosity of about 1000–2000 openings per inch with a mean average pore size of between about 0.5–2 mils (12.5–50 μm), the fluid level H is controlled at about 4 inches (10 cm) to yield a hydrodynamic pressure of about 0.05 psi (0.35 kPa) at the fabric-liquid interface. For other coating processes, the hydrodynamic fluid pressure may be controlled, for example, by a pumping pressure or the like.

In the illustrative knife-over-roll coating process, the lower edge, **120**, of front plate **110** defines a knife surface which is shimmed or otherwise spaced-apart a predetermined distance from the second side **18** of fabric member **12**. Such spacing provides a clearance or gap, referenced at "g," of typically about 10 mils (0.25 mm), but which is adjustable to regulate the thickness of the liquid coating layer, **122**, being applied to the fabric member. From roller **104**, the coated fabric member **12** may be conveyed via a take-up roller arrangement (not shown) through a in-line oven or the like to dry or flash the water or other diluent in the liquid coating layer **122**, or to otherwise cure the liquid coating layer **122** in developing an adherent, tack-free, film or other layer of coating member **14** (FIG. **1**) on the single side **18** of fabric member **12**.

The Example to follow, wherein all percentages and proportions are by weight unless otherwise expressly indicated, is illustrative of the practicing of the invention herein involved, but should not be construed in any limiting sense.

EXAMPLE

Representative EMI shielding materials according to the present invention were constructed for characterization. In this regard, a master batch of a flame retardant coating composition was compounded using an acrylic latex emulsion (Heveatex "4129FR"). The viscosity of the emulsion was adjusted to a Brookfield viscosity (#4 spindle, 40 speed) of about 60,000 cps with about 5wt % of an acryloid thickener (Acrysol™GS, Monsanto Colo., St. Louis, Mo.). The modified emulsion had a total solids content of about 60% by weight, a density of about 10 pounds per gallon (1.8 g/lcm^3), and a pH of between about 7.5 and 9.5.

The emulsion was applied using a knife over roll coater (JETZONE Model 7319, Wolverine Corp., Merrimac, Mass.) to one side of a silver-plated nylon fabric (Swift "31EN RIPSTOP") having a thickness of about 4 mils (0.1 mm). With the fluid level in the coating trough of the coater maintained at about 4 inch (10 cm), the emulsion was delivered to the surface of the cloth at a hydrodynamic pressure of about 0.05 psi (0.35 kPa). The coating knife was shimmed to a 10 mil (0.25 mm) gap above the fabric to yield a wet coating draw down thickness of about 10 mils. Following an oven curing at 100–125° C. for 5 minutes, a dried coating or film thickness of about 2.5 mils (0.635 mm) was obtained with a weight pickup of about 130–145 g/yd^2 and a total material thickness of between about 6–7 mils (0.15–0.18 mm). An inspection of the coated fabric cloth revealed a coating penetration depth of about 1–2 mils (0.02–0.05 mm) providing acceptable mechanical retention and/or adhesion of the coating onto the fabric surface. The opposite side of the fabric, however, was observed to be substantially coating free, and to retain a surface resistivity of about 0.1 Ω/sq for unaffected EMI shielding effectiveness.

Fabric samples similarly coated in the manner described were subjected to an in-house vertical flame test. No burning was observed at dried film thickness of 2, 3, or 4 mils (0.05, 0.08, 0.10 mm). Accordingly, a reasonable operating window of film thickness was suggested for production runs.

Samples also were provided, as jacketed over a polyurethane foam core in an EMI shielding gasket construction, for flame testing by Underwriters Laboratories, Inc., Melville, N.Y. A flame class rating of V-0 under UL94 was assigned at a minimum thickness of 1.0 mm. The gasket construction therefore was found to be compliant with the applicable UL requirements, and was approved to bear the "UL" certification mark.

The foregoing results confirm that the EMI shielding material of the present invention affords UL94 V-0 protection when used as a jacketing in a fabric-over-foam gasket construction. Unexpectedly, it was found that a relatively porous or permeable fabric may be wet coated on one side with a relatively thin, i.e., 2–4 mil (0.05–0.10 mm), coating layer of a flame retardant composition without compromising the electrical surface conductivity of the other side. Such a thin coating layer, while being sufficient to provide UL94 V-0 protection in a conventional fabric-over-foam gasket construction, nonetheless maintains the drapability the fabric and thereby facilitates the fabrication of UL94 V-0 compliant gaskets having complex profiles or narrow cross-sections down to about 1 mm.

As it is anticipated that certain changes may be made in the present invention without departing from the precepts herein involved, it is intended that all matter contained in the foregoing description shall be interpreted as illustrative and not in a limiting sense. All references cited herein are expressly incorporated by reference.

What is claimed is:

1. A flame retardant, electromagnetic interference (EMI) shielding gasket comprising:

a resilient core member extending lengthwise along a central longitudinal axis and having an outer surface extending circumferentially about said longitudinal axis, said core member being formed of a foamed elastomeric material;

an electrically-conductive fabric member surrounding the outer surface of said core member, said fabric member having an interior surface disposed facing the outer surface of said core member and an oppositely-facing, exterior surface, at least the exterior surface being

electrically-conductive and the exterior surface defining with the interior surface a thickness dimension of the fabric member therebetween; and

a flame retardant layer coating at least a portion of the interior surface of said fabric member, said flame retardant layer comprising at least about 50% by dry weight of one or more flame retardant additives and penetrating into said fabric member to a depth which is less than the thickness dimension of said fabric member such that the exterior surface of said fabric member remains electrically-conductive.

2. The gasket of claim 1 wherein said flame retardant layer has a thickness of between about 2–4 mils (0.05–0.10 mm).

3. The gasket of claim 1 wherein said flame retardant layer is formed as a cured film of a flame retardant acrylic latex emulsion.

4. The gasket of claim 1 wherein said fabric member is a metal-plated cloth.

5. The gasket of claim 4 wherein said cloth comprises fibers selected from the group consisting of cotton, wool, silk, cellulose, polyester, polyamide, nylon, and combinations thereof, and said metal is selected from the group consisting of copper, nickel, silver, nickel-plated-silver, aluminum, tin, and combinations thereof.

6. The gasket of claim 1 wherein said foamed elastomeric material is selected from the group consisting of polyethylenes, polypropylenes, polypropylene-EPDM blends, butadienes, styrene-butadienes, nitriles, chlorosulfonates, neoprenes, urethanes, silicones, and polyolefin resin/monoolefin copolymer blends, and combinations thereof.

7. The gasket of claim 1 wherein said fabric member has a thickness of between about 2–4 mils (0.05–0.10 mm).

8. The gasket of claim 1 wherein said flame retardant layer is effective to afford the gasket a flame class rating of V-0 under Underwriter's Laboratories (UL) Standard No. 94.

9. The gasket of claim 1 wherein said one or more flame retardant additives are selected from the group consisting of aluminum hydrate, antimony trioxide, phosphate esters, and halogenated compounds.

10. The gasket of claim 1 wherein said flame retardant layer comprises between about 50–83% by dry weight of one or said one or more flame retardant additives.

* * * * *

EXHIBIT D

EXHIBIT D

THE Oxford Desk Dictionary

American Edition

Edited by

Laurence Urdang

New York Oxford
Oxford University Press
1995

from being exposed to the elements 3 *Photog.* a exposing film to light b duration of this c section of film so affected

ex·pound /ikspound'/ *v.* 1 set out in detail 2 explain or interpret [L *ponere posit-* place; put]

ex·press /ikspres'/ *v.* 1 represent or make known in words or by gestures, conduct, etc. 2 communicate 3 represent by symbols 4 send by express service —*adj.* 5 operating at high speed 6 definitely stated 7 delivered by a specially fast service —*adv.* 8 at high speed 9 by express shipment —*n.* 10 fast train, etc. 11 service for rapid package delivery —**ex·press'i·ble** *adj.*; **ex·press'ly** *adv.* [L *exprimere -press-* squeeze out]

ex·pres·sion /ikspresH'ən/ *n.* 1 expressing or being expressed 2 word or phrase expressed 3 person's facial appearance, indicating feeling 4 depiction or conveying of feeling, etc., in art 5 *Math.* collection of symbols expressing a quantity —**ex·pres'sion·less** *adj.* [rel. to EXPRESS]

ex·pres'sion·ism' *n.* style of painting, music, drama, etc., seeking to express emotion rather than the external world —**ex·pres'sion·ist** *n.* & *adj.*

ex·pres·sive /ikspres'iv/ *adj.* 1 full of expression 2 serving to express —**ex·pres'sive·ly** *adv.*; **ex·pres'sive·ness** *n.*

ex·press'way *n.* high-speed highway

ex·pro·pri·ate /iksprō'prē·āt'/ *v.* (·at·ed, ·at·ing) take away (property) from its owner for official or public reasons —**ex·pro'pri·a'tion** *n.* [L *proprius* proper; one's own]

ex·pul·sion /ikspəl'sHən/ *n.* expelling or being expelled [L, rel. to EXPEL]

ex·punge /ikspənj'/ *v.* (·punged, ·pung·ing) erase; remove [L *expungere* prick out (for deletion)]

ex·pur·gate /ek'spərgāt'/ *v.* (·gat·ed, ·gat·ing) remove objectionable matter from (a book, etc.) —**ex'pur·ga'tion, ex'pur·ga'tor** *n.* [L, rel. to PURGE]

ex·qui·site /ekskwiz'it, ek'skwiz'·/ *adj.* 1 extremely beautiful or delicate 2 keenly felt 3 highly refined —**ex'qui·site·ly** *adv.* [L *exquirere -quisit-* seek out]

ex·tant /ek'stant, ekstant'/ *adj.* still in existence [L *ex(s)tare* stand out]

ex·tem·po·ra·ne·ous /ikstem'pərā'nēəs/ *adj.* spoken or done without preparation —**ex·tem'po·ra'ne·ous·ly** *adv.* [fr. EXTEMPORE]

ex·tem·po·re /ikstem'pərē/ *adj.* & *adv.* without preparation [L: at the moment]

ex·tem·po·rize /ikstem'pərīz'/ *v.* (·rized, ·riz·ing) improvise —**ex·tem'po·ri·za'tion** *n.*

ex·tend /ikstend'/ *v.* 1 lengthen or make larger in space or time 2 stretch or lay out at full length 3 reach or encompass 4 (foll. by *to*) go so far as to include 5 offer (an invitation, hospitality, etc.) —**ex·tend'i·ble, ex·ten'si·ble** *adj.* [L *extendere -tens-* stretch out]

ex·tend'ed fam'i·ly *n.* family including nearby relatives

ex·ten·sion /iksten'sHən/ *n.* 1 extending or being extended 2 part enlarging or added on 3 subsidiary telephone 4 additional interval

ex·ten·sive /iksten'siv/ *adj.* 1 covering a large area 2 far-reaching —**ex·ten'sive·ly** *adv.*; **ex·ten'sive·ness** *n.*

ex·tent /ikstent'/ *n.* 1 space over which a thing extends 2 range; scope; degree [AngFr, rel. to EXTEND]

ex·ten·u·ate /iksten'yōō·āt'/ *v.* (·at·ed, ·at·ing) make (guilt or an offense) seem less serious —**ex·ten'u·a'tion** *n.* [L *tenuis* thin]

ex·te·ri·or /ikstēr'ēər/ *adj.* 1 of or on the outer side 2 coming from outside —*n.* 3 outward aspect or surface 4 outward demeanor [L]

ex·ter·mi·nate /ikstər'mənāt'/ *v.* (·nat·ed, ·nat·ing) destroy utterly (esp. a living thing) —**ex·ter·mi·na'tion, ex·ter'mi·na'tor** *n.* [L *terminus* boundary]

ex·ter·nal /ikstərn'l/ *adj.* 1a of or on the outside or visible part b in or coming from the outside or an outside source 2 foreign 3 not subjective or individual 4 for use on the outside of the body —*n.* 5a (*pl.*) outward features or aspect b external circumstances c inessentials —**ex·ter'nal·ly** *adv.* [L *externus* outer]

ex·ter·nal·ize /ikstərn'l·īz'/ *v.* (·ized, ·iz·ing) give or attribute external existence to —**ex·ter'nal·i·za'tion** *n.*

ex·tinct /ikstiNGkt'/ *adj.* 1 that has died out; defunct 2 (of a volcano) that no longer erupts [L *ex(s)tinguere -stinct-* quench]

ex·tinc·tion /ekstiNGk'sHən/ *n.* 1 making or becoming extinct 2 extinguishing or being extinguished 3 annihilation

ex·tin·guish /ikstiNG'gwiSH/ *v.* 1 cause (a flame, light, etc.) to die out 2 destroy —**ex·tin'guish·a·ble** *adj.*; **ex·tin'guish·er** *n.*

ex·tir·pate /ek'stərpāt'/ *v.* (·pat·ed, ·pat·ing) root out; eradicate —**ex'tir·pa'tion** *n.* [L *ex(s)tirpare* fr. *stirps* stem of tree]

ex·tol /ikstōl'/ *v.* (also **ex·toll'**) (·tolled, ·tol·ling) praise enthusiastically [L *tollere* raise]

ex·tort /ikstôrt'/ *v.* obtain by coercion [L *torquere tort-* twist]

ex·tor·tion /ekstôr'sHən/ *n.* act of extorting, esp. money —**ex·tor'tion·ate** /-sHənit/ *adj.*; **ex·tor'tion·ate·ly** *adv.*; **ex·tor'tion·er, ex·tor'tion·ist** *n.*

ex·tra /ek'strə/ *adj.* 1 additional; more than usual, necessary, or expected —*adv.* 2 more than usually 3 additionally (*was charged extra*) —*n.* 4 extra thing 5 thing for which an extra charge is made 6 performer in a minor role [prob. fr. EXTRAORDINARY]

extra- *comb. form* 1 outside; beyond 2 beyond the scope of [L *extra* outside]

ex·tract *v.* /ikstrakt'/ 1 remove or take out 2 obtain (money, an admission, etc.) using pressure 3 select (a part of a book, etc.) 4 obtain (juice, etc.) by pressure, distillation, etc. 5 derive (pleasure, etc.) —*n.* /ek'strakt'/ 6 short passage from a book, etc. 7 concentrated ingredient [L *trahere tract-* draw]

ex·trac'tion *n.* 1 extracting or being extracted 2 lineage; descent —**ex·trac'tor** *n.* [L, rel. to EXTRACT]

ex·tra·cur·ric·u·lar /ek'strəkərik'yələr/ *adj.* not part of the normal curriculum

ex·tra·dite /ek'strədīt'/ *v.* (·dit·ed, ·dit·ing) return (a person accused or convicted of a crime) to the country, state, etc., in which the crime was committed —**ex'tra·dit'a·ble** *adj.*; **ex'tra·di'tion** *n.* [Fr, rel. to TRADITION]

ex·tra·mar·i·tal /ek'strəmar'ət·l/ *adj.* (esp. of sexual relations) occurring outside marriage

ex·tra·ne·ous /ikstrā'nēəs/ *adj.* 1 of external origin 2 separate; irrelevant; unrelated [L *extraneus*]

ex·tra·or·di·nar·y /ikstrôrd'n·er'ē, ek'strəôrd'·/ *adj.* 1 unusual or remarkable 2 unusually great 3 (of a meeting, official, etc.) special or additional —**ex·tra·or'di·nar'i·ly** /-er'ilē/ *adv.* [L]

ex·trap·o·late /ikstrap'əlāt'/ *v.* (·lat·ed, ·lat·ing) calculate or derive approximately from known data, etc. —**ex·trap'o·la'tion** *n.* [fr. EXTRA- + (INTER)POLATE]

ex·tra·ter·res·tri·al /ek'strətəres'trēəl/ *adj.* 1 outside the earth or its atmosphere or from there —*n.* 2 (in science fiction) being from outer space

ex·trav·a·gant /ikstrav'əgənt/ *adj.* 1 spending money excessively 2 excessive; absurd 3 costing much —**ex·trav'a·gance** *n.*; **ex·trav'a·gant·ly** *adv.* [L *vagari* wander]

ex·trav·a·gan·za /ikstrav'əgan'zə/ *n.* spectacular theatrical production [It: extravagance]

ex·treme /ikstrēm'/ *adj.* 1 of a high or the highest degree 2 severe 3 outermost 4 on the far left or right of a political party —*n.* 5 either of two opposite things; pole; end 6 highest degree 7 *Math.* first or last term of a ratio or series —**ex·treme'ly** *adv.* [L]

ex·trem'ist *n.* person with radical views —**ex·trem'ism** *n.*

ex·trem·i·ty /ikstrem'itē/ *n.* (*pl.* ·ties) 1 extreme point; end 2 (*pl.*) the hands and feet 3 extreme adversity [L, rel. to EXTREME]

ex·tri·cate /ek'strikāt'/ *v.* (·cat·ed, ·cat·ing) free or disentangle from a difficulty, etc. —**ex'tri·ca·ble** *adj.*; **ex'tri·ca'tion** *n.* [L *tricae* perplexities]

ex·trin·sic /ekstrin'sik/ *adj.* 1 coming from outside; not inherent or intrinsic 2 extraneous —**ex·trin'si·cal·ly** *adv.* [L *extrinsecus* outwardly]

ex·tro·vert /ek'strəvərt'/ *n.* outgoing and externally oriented person —**ex'tro·ver'sion** *n.*; **ex'tro·vert'ed** *adj.* [L *vertere* turn]

ex·trude /ikstrōōd'/ *v.* (·trud·ed, ·trud·ing) thrust or force out, as through a small opening —**ex·tru'sion** *n.*; **ex·tru'sive** *adj.* [L *extrudere -trus-* thrust out]

ex·u·ber·ant /igz(y)ōō'bərənt/ *adj.* 1 lively; high-spirited 2 (of a plant, etc.) prolific —**ex·u'ber·ance** *n.*; **ex·u'ber·ant·ly** *adv.* [L *uber* fertile]

ex·ude /igz(y)ōōd'/ *v.* (·ud·ed, ·ud·ing) 1 ooze out 2 freely show (a spirit, emotion, etc.) —**ex'u·da'tion** *n.* [L *sudare* sweat]

ex·ult /igzəlt'/ *v.* be joyful —**ex'ul·ta'tion** /-zəltā'sHən/ *n.*; **ex·ul'tant** *adj.*; **ex·ul'tant·ly** *adv.* [L *ex(s)ultare* fr. *saltare* leap]

eye /ī/ *n.* 1 organ of sight 2 eye characterized by the color of the iris 3 tissues around the eye (*black eye*) 4 (*sing.* or *pl.*) sight 5a particular visual ability b discernment (*good eye for detail*) 6 calm region at the center of a hurricane 7 hole of a needle —*v.* (eyed, eye·ing or ey·ing) 8 watch or observe closely 9 **have an eye or eyes for** be interested in; wish to acquire 10 **see eye to eye** agree 11 **with an eye to** with a view to [OE]

eye'ball' *n.* 1 ball of the eye within the lids and socket —*v.* 2 *Slang.* look or stare (at)

eye'brow' *n.* 1 line of hair on the ridge above the eye socket 2 **raise one's eyebrows** show surprise, disbelief, or disapproval

eye'-catch'ing *adj. Colloq.* striking

eye·ful /ī'fo͝ol'/ *n.* (*pl.* ·fuls) *Colloq.* 1 visually striking person or thing 2 **get an eyeful** (of) good and thorough look

eye'glass'es *n.* pair of framed lenses to assist defective sight

eye'lash' *n.* each of the hairs growing on the edges of the eyelids

eye·let /ī'lit/ *n.* 1 small hole for string, rope, etc., to pass through 2 metal ring strengthening this [OFr *oillet* fr. L *oculus*]

eye'lid' *n.* either of the skin folds closing to cover the eye

eye'lin'er *n.* cosmetic for the eyes, usu. applied in a thin line next to the lashes

eye'-o'pen·er *n. Colloq.* enlightening experience; startling revelation

eye'piece' *n.* lens or lenses to which the eye is applied at the end of an optical instrument

eye'sight' *n.* faculty or power of seeing

eye'sore' *n.* ugly thing

eye'tooth' *n.* canine tooth in the upper jaw

eye'wash' *n.* 1 solution to cleanse the eyes 2 *Slang.* nonsense; insincere talk

eye'wit'ness /ī'wit'nəs/ *n.* person who saw a thing happen

ey·rie /âr'ē, ēr'ē/ *n.* see AERIE

Ey·senck /ī'zeNGk'/, **Hans Jürgen** 1916–92; German-born British psychologist

F

f, F /ef/ *n.* (*pl.* **f's; F's, Fs**) sixth letter of the English alphabet; a consonant

F /ef/ *symb.* fluorine

f or **f.** *abbr.* 1 farthing 2 father 3 fathom 4 feet 5 female; feminine 6 filly 7 fine 8 focal length 9 folio 10 (*pl.* **ff.**) following 11 franc(s)

F or **F.** *abbr.* 1 Fahrenheit 2 farad(s) 3 February 4 franc(s) 5 France; French 6 Friday

fa /fä/ *n. Mus.* fourth note of a major scale

FAA *abbr.* Federal Aviation Administration

Fa·ber·gé /fab'ərzHā'/, **Peter Carl** 1846–1920; Russian goldsmith and jeweler

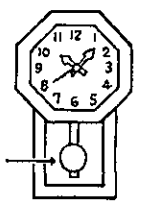
fa·ble /fā'bəl/ *n.* 1a fictional, esp. supernat-

Case 1:07-cv-00104-MPT Document 48-2 Filed 07/01/2008 Page 39 of 41

horticulture, etc. —**peat'y** *adj.* [perh. Celt, rel. to PIECE]
peat'bog *n.* bog composed of peat
peat'moss' *n.* dried peat from mosses
peb·ble /peb'əl/ *n.* small stone worn smooth, esp. by the action of water —**peb'bly** *adj.* [OE]
pe·can /pikän', -kan'; pē'kan'/ *n.* 1 pinkish-brown, smooth nut with an edible kernel 2 type of hickory producing this [Algonquian]
pec·ca·dil·lo /pek'ədil'ō/ *n.* (*pl.* ·loes or ·los) trifling offense; venial sin [Sp *pecadillo*, fr. L *peccare* to sin]
peck[1] /pek/ *v.* 1 strike or bite with a beak 2 kiss hastily or perfunctorily 3 make, remove, or pluck by pecking 4 *Colloq.* eat listlessly; nibble at —*n.* 5 stroke, mark, or bite made by a beak 6 hasty or perfunctory kiss [prob. LGer]
peck[2] *n.* dry measure equal to 8 quarts [AngFr]
peck'ing or'der *n.* social hierarchy
pec·tin /pek'tin/ *n.* soluble gelatinous carbohydrate found in ripe fruits, etc., and used as a setting agent in jams and jellies —**pec'tic** *adj.* [Gk *pectos* congealed]
pec·to·ral /pek'tərəl/ *adj.* 1 of or worn on the breast or chest —*n.* 2 pectoral muscle or fin [L *pectus -tor-* chest]
pec·u·late /pek'yəlāt'/ *v.* (·lat·ed, ·lat·ing) embezzle —**pec'u·la'tion, pec'u·la'tor** *n.* [L, rel. to PECULIAR]
pe·cu·liar /pikyōōl'yər/ *adj.* 1 strange; odd; unusual 2a belonging exclusively b belonging to the individual 3 particular; special —**pe·cu'liar·ly** *adv.* [L *peculium* private property, fr. *pecu* cattle]
pe·cu·li·ar·i·ty /pikyōō'lē·ar'ətē/ *n.* (*pl.* ·ties) 1 oddity; idiosyncrasy 2 characteristic
pe·cu·ni·ar·y /pikyōō'nē·er'ē/ *adj.* of or concerning money [L *pecunia* money, fr. *pecu* cattle]
ped·a·gogue /ped'əgäg'/ *n.* schoolmaster; pedantic teacher —**ped·a·gog·ic** /ped'əgō'jik/, **ped'a·gog'i·cal** *adj.* [Gk *pais paid-* child, *agein* lead]
ped·a·go·gy /ped'əgäj'ē, -gō'jē/ *n.* science of teaching
ped·al *n.* /ped'l/ 1 lever or control operated by foot, esp. in a vehicle, on a bicycle, etc. —*v.* /ped'l/ (·aled or ·alled, ·al·ing or ·al·ling) 2 operate the pedals of 3 propel (a bicycle, etc.) with the pedals —*adj.* /pēd'l/ 4 of the foot or feet [L *pes ped-* foot]
ped·ant /ped'nt/ *n.* person, esp. a teacher, who insists on adherence to formal rules or literal meaning —**pe·dan·tic** /pədant'ik/ *adj.*; **pe·dan'ti·cal·ly** *adv.*; **ped'ant·ry** *n.* [Fr fr. It]
ped·dle /ped'l/ *v.* (·dled, ·dling) 1a sell (goods) while traveling b advocate or promote 2 sell (drugs) illegally —**ped'dler** *n.*
ped·er·as·ty /ped'ərəs'tē/ *n.* anal intercourse between a man and a boy —**ped'er·ast** *n.* [Gk *pais paid-* boy, *erastēs* lover]
ped·es·tal /ped'əstəl/ *n.* base supporting a column, pillar, statue, etc. [It *piedestallo* foot of stall]
pe·des·tri·an /pədes'trēən/ *n.* 1 person who is walking —*adj.* 2 prosaic; dull; uninspired 3 of or for pedestrians —**pe·des'tri·an·ize** *v.* (·ized, ·iz·ing) [L, rel. to PEDAL]
pe·di·at·rics /pē'dē·a'triks/ *n. pl.* (treated as *sing.*) branch of medicine dealing with children and their diseases —**pe'di·at'ric** *adj.*; **pe'di·a·tri'cian** /-ətrish'ən/ *n.* [Gk *pais, paid-* child, *iatros* physician]
ped·i·cure /ped'ikyōōr'/ *n.* care or treatment of the feet, esp. the toenails [L *pes ped-* foot, *cura* care]
ped·i·gree /ped'igrē'/ *n.* 1 recorded line of descent 2 genealogical table —**ped'i·greed** *adj.* [fr. MFr *pie de grue* crane's foot, thought to resemble lines in a family tree]

PEDIMENT

ped·i·ment /ped'əmənt/ *n.* triangular part crowning the front of a building, esp. over a doorway, etc. [fr. *periment*, perh. a corruption of PYRAMID]
ped·lar /ped'lər/ *n.* a former spelling of PEDDLER
pe·dom·e·ter /pidäm'ətər/ *n.* instrument for measuring distance walked [L *pes ped-* foot, rel. to -METER]
pe·dun·cle /pē'dəNG'kəl, pidəNG'-/ *n.* stalk of a flower, fruit, or cluster —**pe·dun'cu·lar** /-kyələr/ *adj.* [L *pedunculus*, dim. of *pes, ped-* foot]
peek /pēk/ *v.* 1 look slyly; glance —*n.* 2 quick or sly look
peel /pēl/ *v.* 1a strip the skin, rind, wrapping, etc., from b strip (skin, peel, etc.) 2a become bare of skin, paint, etc. b flake off —*n.* 3 rind of a fruit, vegetable, etc. —**peel'er** *n.* [OE fr. L *pilo* strip of hair]
Peel /pēl/, (Sir) **Robert** 1788–1850; British prime minister (1834–35; 1841–46)
peel'ing *n.* (usu. *pl.*) stripped-off piece of peel
peen /pēn/ *n.* ball- or wedge-shaped end of a hammerhead [prob. Scan]
peep[1] /pēp/ *v.* 1 look through a narrow opening; look furtively 2 come slowly into view; emerge —*n.* 3 furtive or peering glance
peep[2] *v.* 1 make a shrill feeble sound as of young birds, mice, etc. —*n.* 2 such a sound 3 slight sound, utterance, or complaint [imit.]
peep'hole' *n.* small hole for peeping through
peep'ing Tom' *n.* furtive voyeur
peer[1] /pēr/ *v.* look closely or with difficulty
peer[2] *n.* 1a (*fem.* **peer'ess**) member of the British nobility b noble of any country 2 person who is equal in ability, standing, rank, or value —**peer'age** /-ij/ *n.* [L *par* equal]
peer'less *adj.* unequalled; superb
peeve /pēv/ *Colloq. v.* (**peeved, peev·ing**) 1 irritate; annoy —*n.* 2 cause or state of irritation [back formation fr. PEEVISH]
pee'vish *adj.* irritable —**pee'vish·ly** *adv.*
pee·wee /pē'wē/ *n.* any thing or person that is unusually small
peg /peg/ *n.* 1 pin or bolt of wood, metal, etc., for holding, hanging, or supporting things 2 pin for marking position, e.g., on a map, cribbage board, etc. 3 degree or notch 4 *Slang.* fast, accurate throw —*v.* (**pegged, pegging**) 5 fix, stabilize, secure, etc., with or as if with pegs 6 throw accurately 7 **peg away** (at) work consistently [prob. LGer or Du]
Peg·a·sus /peg'əsəs/ *Gk. Myth.* legendary winged horse
peg'board' *n.* board with small holes for pegs or other fittings, used for displays, storage, etc.
Pei /pā/, **I(eoh) M(ing)** 1917– ; Chinese-born US architect
pe·jo·ra·tive /pijôr'ətiv, -jär'-/ *adj.* 1 derogatory —*n.* 2 derogatory word —**pe'jo·ra'tion** /-rā'shən/ *n.*; **pe·jor'a·tive·ly** *adv.* [L *pejor* worse]
Pe·king /pākiNG', pē-/ *n.* see BEIJING
Pe·king·ese /pē'kinēz', -ēs'/ *n.* (also **Pe'kinese'**) (*pl.* same) short-legged lap dog with long hair and a snub nose [fr. *Peking* (Beijing) in China]
pe·koe /pē'kō/ *n.* black tea grown in Sri Lanka and India
pe·lag·ic /pəlaj'ik/ *adj.* of the open ocean
pelf /pelf/ *n. Derog.* or *Joc.* money; wealth [Fr, rel. to PILFER]
pel·i·can /pel'ikən/ *n.* water bird with a large bill and a pouch in its throat for carrying fish [Gk *pelekan*]
pel·la·gra /pəlag'rə, -lā'grə/ *n.* disease caused by niacin deficiency, marked by cracking of the skin and mental disorders [It fr. L *pellis* skin, Gk *agra* seizure]
pel·let /pel'it/ *n.* 1 small compressed ball of paper, medicine, etc. 2 piece of small shot [Fr *pelote* fr. L *pila* ball]
pell-mell /pel'mel'/ *adv.* 1 headlong; recklessly 2 in disorder or confusion [Fr *pêle-mêle*]
pel·lu·cid /pilōō'sid/ *adj.* 1 transparent 2 clear; easily understood [L, rel. to PER-]
pelt[1] /pelt/ *v.* 1 strike repeatedly with thrown objects 2 fall quickly and torrentially
pelt[2] *n.* undressed skin, usu. of a fur-bearing mammal [Fr, ult. fr. L *pellis* skin]
pel·vis /pel'vis/ *n.* basin-shaped cavity in most vertebrates, formed from the hip bones, sacrum, and other vertebrae —**pel'vic** *adj.* [L: basin]
pen[1] /pen/ *n.* 1 instrument for writing, etc., with ink —*v.* (**penned, pen·ning**) 2 write [L *penna* feather]
pen[2] *n.* 1 small enclosure for cows, sheep, poultry, etc. —*v.* (**penned, pen·ning**) 2 enclose or shut up, esp. in a pen [OE]
pen[3] *n. Slang.* penitentiary
pe·nal /pēn'l/ *adj.* of or concerning punishment or its infliction —**pe'nal·ly** *adv.* [L *poena* PAIN]
pe·nal·ize /pēn'l·īz'/ *v.* (·ized, ·iz·ing) subject (a person) to a penalty or disadvantage
pen·al·ty /pen'l·tē/ *n.* (*pl.* ·ties) 1 punishment 2 disadvantage, loss, etc., esp. as a result of one's own actions 3 *Sports.* disadvantage imposed for a breach of the rules, etc. [MedL, rel. to PENAL]
pen·ance /pen'ans/ *n.* act of self-punishment as reparation for guilt, sins, etc. [rel. to PENITENT]
pen·chant /pen'CHənt/ *n.* inclination or liking [Fr]
pen·cil /pen'səl/ *n.* 1 instrument for writing or drawing, usu. a thin rod of graphite, etc., enclosed in a wooden cylinder or metal case —*v.* (·ciled or ·cilled, ·cil·ing or ·cil·ling) 2 write, draw, or mark with a pencil 3 write, note, or arrange provisionally [L *penicillum* paintbrush]
pend /pend/ *v.* await decision or settlement
pen·dant /pen'dənt/ *n.* hanging jewel, etc., esp. one attached to a necklace, bracelet, etc. [Fr *pendre* hang]
pen·dent /pen'dənt/ *adj.* 1a hanging b overhanging 2 undecided; pending —**pen'den·cy** *n.*
pend'ing *adj.* 1 awaiting decision or settlement; undecided —*prep.* 2 during 3 until [after Fr: see PENDANT]
pen·du·lous /pen'jələs/ *adj.* hanging down; drooping and swinging [L *pendulus* fr. *pendere* hang]
pen·du·lum /pen'jələm/ *n.* (*pl.* ·lums) weight suspended so as to swing freely, esp. one regulating a clock [L neut. adj., rel. to PENDULOUS]



PENDULUM

pen·e·trate /pen'ətrāt'/ *v.* (·trat·ed, ·trat·ing) 1a find access into or through b pierce c permeate 2 see into or through; find out; discern 3 be absorbed by the mind —**pen'e·tra·ble** /-trəbəl/ *adj.*; **pen'e·tra·bil'i·ty, pen'e·tra'tion** *n.*; **pen'e·tra·tive** *adj.* [L]
pen'e·trat'ing *adj.* 1 insightful; sensitive 2 easily heard; piercing
pen·guin /peNG'gwin, pen'-/ *n.* flightless black and white sea bird of the southern hemisphere with flipperlike wings used in swimming

PENGUIN

pen·i·cil·lin /pen'əsil'ən/ *n.* antibiotic produced naturally from mold or synthetically [L *penicillum*, rel. to PENCIL]
pen·in·su·la /pənin's(y)ələ/ *n.* piece of land almost surrounded by water —**pen·in'su·lar** *adj.* [L *paene* almost, *insula* island]
pe·nis /pē'nis/ *n.* male organ of copulation and (in mammals) urination —**pe·nile** /pē'nīl/ *adj.* [L]
pen·i·tent /pen'ətənt/ *adj.* 1 repentant —*n.* 2 repentant person —**pen'i·tence** *n.*; **pen'i·ten'tial** /-ten'shəl/ *adj.*; **pen'i·tent·ly** *adv.* [L *paenitere* repent]
pen·i·ten·tia·ry /pen'əten'shərē/ *n.* (*pl.* ·ries) 1 federal or state prison —*adj.* 2 of penance 3 of reformatory treatment [L, rel. to PENITENT]
pen'knife' *n.* (*pl.* **knives** /-nīvz'/) pocketknife
pen·light /pen'līt'/ *n.* small flashlight
pen'man·ship' *n.* art of fine handwriting
Penn /pen/, **William** 1644–1718; English founder of Pennsylvania (1682)
Penn., Penna. abbr. for Pennsylvania
pen' name' *n.* literary pseudonym
pen·nant /pen'ənt/ *n.* 1 long, tapering flag 2

Case 1:07-cv-00104-MPT Document 48-2 Filed 07/01/2008 Page 40 of 41

sunk'en *adj.* 1 at a lower level; submerged 2 (of the cheeks) hollow; depressed [past part. of SINK]
sun'lamp' *n.* lamp giving ultraviolet rays for therapy, tanning, etc.
sun'light' *n.* light from the sun
sun'lit' *adj.* illuminated by sunlight
Sun·ni /sōōn'ē/ *n.* (*pl.* same or **·nis**) 1 one of the two main branches of Islam (cf. **Shiite**) 2 adherent of this branch —**Sun·nite** /-īt/ *adj.* [Ar *Sunna* way, rule]
sun·ny /sən'ē/ *adj.* (**·ni·er, ·ni·est**) 1 bright with or warmed by sunlight 2 cheery; bright —**sun'ni·ly** *adv.*; **sun'ni·ness** *n.*
Sun·ny·vale /sən'ēvāl'/ *n.* city in Calif. Pop. 117,229
sun'rise' *n.* 1 sun's rising 2 time of this
sun'roof' *n.* panel in a car's roof that opens
sun'screen' *n.* (also **sun'block'**) lotion, etc., to protect the skin against ultraviolet rays and sunburn
sun'set' *n.* 1 sun's setting 2 time of this —*adj.* 3 of or designating a law that requires termination of its provisions, programs, etc., after a specified period of time, unless specifically renewed by legislation
sun'shine' *n.* 1a light of the sun b area lit by the sun 2 fine weather 3 cheerfulness
sun'spot' *n.* any of the dark patches cyclically appearing on the sun's surface
sun'stroke' *n.* acute prostration from excessive exposure to the sun
sun'tan' *n.* brownish skin color caused by exposure to the sun —**sun'tanned'** *adj.*
sun'up' *n.* sunrise
Sun Yat-sen /sōōn' yät'sen'/ (also **Sun Yi-xian**) 1866–1925; Chinese revolutionary leader
sup /səp/ *v.* (**supped, sup·ping**) *Archaic.* eat supper [Fr]
sup- *prefix* var. of SUB- before *p*
su·per /sōō'pər/ *Colloq. adj.* 1 (also as *interj.*) excellent; splendid —*n.* 2 superintendent [L: above]
super- *comb. form* forming nouns, adjectives, and verbs, meaning: 1 above, beyond, or over (*superstructure; supernatural*) 2 to an extreme degree (*superabundant*) 3 extra good or large of its kind (*supertanker*) 4 of a higher kind (*superintendent*) [L]
su'per·a·bun'dant *adj.* abounding beyond what is normal —**su'per·a·bun'dance** *n.* [L, rel. to SUPER-, ABOUND]
su·per·an·nu·ate /sōō'pəran'yōō-āt'/ *v.* (**·at·ed, ·at·ing**) 1 pension (a person) off 2 dismiss or discard as too old 3 deem too old for work or use —**su'per·an'nu·a'tion** *n.* [L *annus* year]
su·perb /sōōpərb'/ *adj.* 1 excellent 2 magnificent —**su·perb'ly** *adv.* [L: proud]
su'per·charge' *v.* (**·charged, ·charg·ing**) 1 charge (the atmosphere, etc.) with energy, emotion, etc. 2 increase the power of an engine by using a supercharger
su'per·charg'er *n.* device supplying compressed air to an internal-combustion engine for added power
su·per·cil·ious /sōō'pərsil'ēəs/ *adj.* contemptuous; haughty —**su'per·cil'ious·ly** *adv.*; **su'per·cil'ious·ness** *n.* [L *supercilium* eyebrow]
su·per·con·duc·tiv·i·ty /sōō'pərkän'dəktiv'itē/ *n. Physics.* lowered electrical resistance in some substances, esp. at very low temperatures —**su'per·con·duct'ing** *adj.*; **su'per·con·duc'tor** *n.*
su'per·e'go *n.* (*pl.* **·gos**) *Psychol.* part of the mind that acts as a conscience
su·per·er·o·ga·tion /sōō'pərer'əgā'shən/ *n.* doing more than duty requires [L *supererogare* pay in addition]
su·per·fi·cial /sōō'pərfish'əl/ *adj.* 1 of or on the surface; lacking depth 2 swift; cursory 3 apparent but not real (*superficial resemblance*) 4 (esp. of a person) shallow —**su'per·fi'ci·al'i·ty** /-al'itē/ *n.* (*pl.* **·ties**); **su'per·fi'cial·ly** *adv.* [L, rel. to FACE]
su·per·flu·i·ty /sōōprəflōō'ətē/ *n.* (*pl.* **·ties**) 1 state of being superfluous 2 superfluous amount or thing [L *fluere* to flow]
su·per·flu·ous /sōōpər'flōōəs/ *adj.* more than is required; unnecessary [L *fluere* to flow]
su'per·hu'man *adj.* 1 above what is human; supernatural; divine 2 exceeding normal human capability
su'per·im·pose' *v.* (**·posed, ·pos·ing**) lay (a thing) on something else —**su'per·im'po·si'tion** *n.*
su·per·in·tend /sōō'pərintend'/ *v.* supervise; direct —**su'per·in·ten'dence** *n.*
su'per·in·tend'ent *n.* 1 person who superintends; director 2 maintenance custodian of a building
su·pe·ri·or /sōōpēr'ēər/ *adj.* 1 in a higher position; of higher rank 2a of high quality b supercilious; haughty 3 better or greater in some respect 4 written or printed above the line —*n.* 5 person superior to another, esp. in rank 6 head of a monastery, etc. (*mother superior*) —**su·pe'ri·or'i·ty** /-ôr'itē/ *n.* [L comp. of *superus* above]
Su·pe·ri·or, Lake /sōōpēr'ēər/ *n.* largest and northernmost of the Great Lakes
su·per·la·tive /sōōpər'lətiv/ *adj.* 1 of the highest quality or degree; excellent 2 *Gram.* (of an adjective or adverb) expressing the highest degree of a quality (e.g., *bravest, most fiercely*) —*n.* 3 *Gram.* superlative form of an adjective or adverb 4 (*pl.*) high praise; exaggerated language [Fr fr. L]
su'per·man' *n.* (*pl.* **·men**) man of exceptional strength or ability
su'per·mar'ket *n.* large self-service store selling food, housewares, etc.
su'per·nat'u·ral *adj.* 1 not attributable to or explicable by the laws of nature —*n.* 2 (prec. by *the*) supernatural realm, forces, etc. —**su'per·nat'u·ral·ly** *adv.*
su·per·no·va /sōō'pərnō'və/ *n.* (*pl.* **·vae** /-vē/ or **·vas**) exploding star that increases suddenly in brightness
su·per·nu·mer·ar·y /sōō'pərn(y)ōō'mərer'ē/ *adj.* 1 in excess of the normal number; extra —*n.* (*pl.* **·ies**) 2 supernumerary person or thing 3 actor without a speaking part; extra [L, rel. to NUMBER]
su'per·pow'er *n.* extremely powerful nation
su'per·script' *adj.* 1 written or printed above —*n.* 2 superscript number or symbol [L *scribere* write]

su·per·sede /sōō'pərsēd'/ *v.* (**·sed·ed, ·sed·ing**) take the place of; succeed or supplant; make obsolete —**su'per·ses'sion** /-sesh'ən/ *n.* [L *supersedere*]
su'per·son'ic *adj.* of or having a speed greater than that of sound —**su'per·son'i·cal·ly** *adv.*
su'per·star' *n.* extremely famous actor, musician, etc.
su·per·sti·tion /sōō'pərstish'ən/ *n.* 1 belief in the supernatural; irrational fear of the unknown 2 practice or belief based on this —**su'per·sti'tious** *adj.*; **su'per·sti'tious·ly** *adv.* [L]
su'per·struc'ture *n.* 1 structure built on top of another 2 part of a building above the foundation
su'per·tank'er *n.* very large tanker ship
su·per·vene /sōō'pərvēn'/ *v.* (**·vened, ·ven·ing**) *Formal.* occur as something unexpected or additional —**su'per·ven'tion** /-ven'shən/ *n.* [L *supervenire*]
su·per·vise /sōō'pərvīz'/ *v.* (**·vised, ·vis·ing**) superintend; oversee —**su'per·vi'sion** /-vizh'ən/, **su'per·vi'sor** *n.*; **su'per·vi'so·ry** *adj.* [L *supervidere -vis-*]
su·pine /sōōpīn', sōō'pīn'/ *adj.* 1 lying face upwards 2 inert; indolent [L]
supp. or **suppl.** *abbr.* 1 supplement 2 supplementary
sup·per /səp'ər/ *n.* evening meal [Fr *souper*]
sup·plant /səplant'/ *v.* take the place of, esp. by underhand means [L *supplantare* trip up]
sup·ple /səp'əl/ *adj.* (**·pler, ·plest**) 1 flexible; pliant 2 limber 3 adaptable, esp. mentally —**sup'ple·ness** *n.* [L *supplex*]
sup·ple·ment *n.* /səp'ləmənt/ 1 thing or part added to improve or provide further information 2 separate section of a newspaper, etc. —*v.* /səp'ləment'/ 3 provide a supplement for —**sup'ple·men'tal, sup'ple·men'ta·ry** *adj.*; **sup'ple·men·ta'tion** /-mentā'shən/ *n.* [L *supplere* supply]
sup·pli·ant /səp'lēənt/ *adj.* 1 supplicating —*n.* 2 supplicating person [L, rel. to SUPPLICATE]
sup·pli·cate /səp'likāt'/ *v.* (**·cat·ed, ·cat·ing**) petition humbly; entreat —**sup'pli·cant** *adj.* & *n.*; **sup'pli·ca'tion** *n.*; **sup'pli·ca·to'ry** /-kətô'rē/ *adj.* [L *supplicare*]
sup·ply /səplī'/ *v.* (**·plied, ·ply·ing**) 1 provide (a thing needed) 2 provide (a person, etc., with a thing) 3 meet or make up for (a deficiency or need) —*n.* (*pl.* **·plies**) 4 providing of what is needed 5 stock, store, amount, etc. 6 (*pl.*) provisions; equipment —**sup·pli'er** *n.* [L *supplere* fill up]
sup·ply-side' *adj. Econ.* denoting a policy of low taxation, etc., to encourage production and investment
sup·port /səpôrt'/ *v.* 1 carry all or part of the weight of; keep from falling, sinking, or failing 2 provide for (a family, etc.) 3 strengthen; encourage 4 bear out; substantiate 5 give help or approval to; further 6 speak in favor of —*n.* 7 supporting or being supported 8 thing or person that supports —**sup·port'er** *n.* [L *portare* carry]
sup·port'ive *adj.* providing (esp. emotional) support or encouragement —**sup·por'tive·ly** *adv.*; **sup·por'tive·ness** *n.*
sup·pose /səpōz'/ *v.* (**·posed, ·pos·ing**) 1 assume; be inclined to think 2 take as a possibility or hypothesis 3 require as a condition (*that supposes we're on time*) 4a be expected or required (*was supposed to write to you*) b (with *neg.*) ought not; not be allowed to [Fr, rel. to POSE]
sup·pos·ed·ly /səpō'zədlē/ *adv.* allegedly
sup·po·si·tion /səp'əzish'ən/ *n.* 1 thing supposed 2 act of supposing
sup·pos·i·to·ry /səpäz'ətôr'ē/ *n.* (*pl.* **·ries**) medical preparation melting in the rectum or vagina [L *suppositorius* placed underneath]
sup·press /səpres'/ *v.* 1 put an end to, esp. forcibly 2 prevent from being done, seen, heard, or known —**sup·press'i·ble** *adj.*; **sup·pres'sion** /-shən/, **sup·pres'sor** *n.* [L, rel. to PRESS[1]]
sup·pu·rate /səp'yərāt'/ *v.* (**·rat·ed, ·rat·ing**) 1 form pus 2 fester —**sup'pu·ra'tion** *n.* [L, rel. to PUS]
supra- *prefix* above
su·pra·na·tion·al /sōō'prənash'(ə)nəl/ *adj.* transcending national limits
su·prem·a·cy /sōōprem'əsē/ *n.* (*pl.* **·cies**) being supreme
su·preme /sōōprēm'/ *adj.* 1 highest in authority or rank 2 greatest; most important 3 (of a penalty or sacrifice) involving death —**su·preme'ly** *adv.* [L]
Su·preme' Court' *n.* 1 highest court of the US 2 highest court in a state
suprv. *abbr.* supervisor
supt. *abbr.* superintendent
sur-[1] *prefix* SUPER- (*surcharge; surrealism*) [Fr]
sur-[2] *prefix* var. of SUB- before *r*
Su·ra·ba·ya /sōōr'əbī'ə/ *n.* seaport in Indonesia, on Java. Pop. 2,027,900
Su·rat /sōōr'ət, sōōrät'/ *n.* seaport in W India. Pop. 1,496,900
sur·charge *n.* /sər'chärj'/ 1 additional charge or payment —*v.* /sərchärj'/ (**·charged, ·charg·ing**) 2 exact a surcharge from [Fr, rel. to SUR-[1]]
surd /sərd/ *Math. adj.* 1 (of a number) irrational —*n.* 2 surd number, esp. the root of an integer [L: deaf]
sure /shōōr, shər/ *adj.* 1 convinced 2 having adequate reason for a belief or assertion 3 confident 4 reliable; unfailing 5 certain; positive 6 undoubtedly true or truthful —*adv.* 7 *Colloq.* certainly 8 **make sure** make certain; ensure 9 **to be sure** admittedly; indeed —**sure'ness** *n.* [Fr fr. L *securus*]
• Usage: In formal contexts use the adverb *surely*, not *sure*: *He surely was silly to run away.*
sure'fire' *adj.* certain to succeed
sure'foot'ed *adj.* never stumbling or making a mistake
sure'ly *adv.* 1 with certainty or safety 2 certainly; to be sure
• Usage: See note at SURE.
sure·ty /shōōr'ətē, shər'-/ *n.* (*pl.* **·ties**) 1 certainty 2 money given as a pledge, guarantee, etc. 3 person who takes responsibility for another's debt, obligation, etc. [Fr fr. L]
surf /sərf/ *n.* 1 foam of the sea breaking on the shore or reefs —*v.* 2 practice surfing —**surf'er** *n.*
sur·face /sər'fis/ *n.* 1 outside of a thing 2 any of the limits of a solid 3 top of a liquid, the ground, etc. 4 outward or superficial as-

Case 1:07-cv-00104-MPT Document 48-2 Filed 07/01/2008 Page 41 of 41